POWER

Volume 61 New York, February 10, 1925 No. 6

Get Started

ALMOST anybody can appreciate the fact that a pound of coal ought to evaporate about so much water.

No coal will evaporate 15 pounds; and if any coal does not evaporate more than half of this, there must be a reason.

One does not need to be a graduate engineer to find out how much water he is evaporating per pound of coal if he can measure the amount of steam that he makes and weigh the coal that he burns.

The monthly coal bill and the reading of the meter — if there is one — on the general water supply system is, however, often the best information existent upon the subject, and it is often not available to the man in charge of the boiler room.

If such a man showed enough intelligent interest in his work and such a desire to obtain better results as to seek such information, it would be an odd kind of management that would not encourage him.

They might even go so far as to get him a special meter for the boiler feed or a steam meter, and scales upon which to weigh his coal.

And when he found — if he did find — that he was not getting as good results as his fellow operators were getting with similar plants, there would commence an interesting search for the reasons.

And here is where he would have a chance to prove himself a real engineer.

He might not be able to determine for himself just how many B.t.u.'s there were per pound in the coal that he got, but he could see if he was being charged for an excessive amount of moisture and ash, if the ashpit refuse contained an unnecessary amount of unburned coal; and by feeling around he could judge whether he was heating up an excessive amount of air in the furnace or passes or sending off gases unburned for lack of it.

And when he got into this investigating frame of mind and developed a passion for research, he could get some good out of the available instruments and apparatus, gas analyzers, draft gages, thermometers, etc., with which boiler plants are sometimes equipped in the apparent hope that their mere presence will result in improved efficiency.

There are only four ways for the heat that is fed into the furnace in the coal to get away, and it must get away or it would melt the furnace down.

It must go out either through the steam main or the chimney, or be dissipated by radiation or carried out with the ashes.

The object is to get as much as possible of it into the steam. The steam tables will show how much of it goes into each pound of steam when the pressure and temperature or quality of the steam and the temperature of the feed water are known.

Intelligent attention to uncovered radiating surfaces, ashpit refuse, the tightness of settings and baffles, the methods of firing, etc., will reduce the amount of heat escaping in the other way and throw more of it into the steam.

And when, by attention to these common things, improvement has been shown, the manager's interest will be aroused and he will have the confidence and disposition to provide the means for further analysis and betterment.

Don't wait for a lot of scientific-looking outfits. Get started with what you can get. The other will come when you have shown the boss that you really need it and why — and can use it to his advantage.

F. R. Low

Recording Service in the Hotel Roosevelt Engine Room

NEW YORK'S latest hotel installs accounting system in the engine room. Service is charged to the department supplied. The chief engineer knows why and where each dollar is spent.

HEATING, lighting and power are so generally classified under the broad term of service that it is difficult for the owners and managers of industrials to view such activities as being just as much a part of the cost of the factory output as is raw material and labor. As a consequence too little attention is given to power-plant costs and methods of improving the economy of operation. In the case of a hotel the matter is still more baffling for most of the output of the power plant is not dependent upon the number of guests registered. It is little wonder, then, that in the usual hotel the cost of supplying light, heat and power is not assessed against the operating costs of each separate department, such as kitchen, hot and cold water pumping, laundry, etc., but is laid against the power department with no credits given for the services performed. In fact, it is this general practice that has led industries of every sort to regard the power plant as a heavy burden, instead of a profit producing portion of the factory.

Hotel Buys Its Steam

The Roosevelt, one of the newest of New York City hotels, is controlled by a hotel syndicate which has brought into hotel keeping all the searching analysis of business conditions and cost accounting found necessary in large undertakings in other commercial spheres. Consequently, when the building was still on the designer's drafting board, consulting engineers were engaged to study the whole problem of light, heat and power. The problem to be solved was the choice of energy supply and heating supply. Electric energy could be purchased or an engine room incorporated in the hotel plant. Heating could be obtained from a hotel boiler plant or purchased from the New York Steam Corporation. After due investigation it was considered advisable to purchase steam and to generate the electric energy in an engine room which was to be placed five stories below ground level, especially in view of the fact that a boiler room would need be excavated in solid rock five floors below ground level.

Steam enters the building at 125 lb. gage and is used in three engine-generator lighting sets, as well as in three engine-driven ammonia compressors, and small steam pumps. The exhaust of these engines flows into a common exhaust main and enters the hotel's heating system at about ½ lb. gage. The advantage of this arrangement is that the only heat lost by the steam before it enters the heating lines is that converted into electric energy, which conversion is done at about 90 per cent efficiency. In other words, where even a superpower central station would require around 15,000 B.t.u. per kilowatt-hour, the engines use not over 3,800.

The three generating sets consist of unaflow engines connected to 300-kw. 250-volt 3-wire generators. Generally, one of the 300-kw. units is sufficient to carry the elevator, motor and lighting load, one of the remaining units helping on the peak load. Two of the ice machines are horizontal double-acting compressors, while the third is a vertical two-cylinder single-acting machine; all are direct connected to unaflow engines. The ammonia condenser is of double-pipe construction and is so piped that the cooling water is discharged into the house hot-water tank. In this way the heat removed in the condenser, which is usually wasted, is saved, at a decided advantage to the general plant efficiency. The ammonia liquid is expanded in a shell-type cooler by which the ice water for the drinking system is chilled. A shell-type brine cooler is also used, the cold brine being pumped through the hotel's refrigerators and cold-storage rooms. A sharp freezer with direct expansion serves the ice-cream department. In addition there is a 20-ton ice-freezing tank on the floor above the engine room. Both the brine and ice water are handled by duplex direct-acting steam pumps.

Suitable bypass connections are provided in the exhaust line of each engine for emergency use. An atmospheric relief line is incorporated in the exhaust line layout to relieve the engines in case the heating demand drops, the back pressure usually carried being ½ lb. gage. Since there is always a possibility that the heating demands may exceed the engine output, and this does occur early in the morning, the live steam line is connected to the exhaust line through a pressure-regulating valve.

Hot Water Arrangements

The hotel laundry requires a large amount of hot water, as do also the many floors of guest rooms, and hot-water tanks are provided in which exhaust steam circulates through the shell, heating the water within the tubes. Two motor-driven centrifugal pumps deliver this hot water to the tank on the building roof.

The condensation from the heating system returns to one of two receivers under a vacuum and is removed by either of the two motor-driven centrifugal pumps shown in Fig. 2. As the company supplying the live steam does not provide means for the return of the hot condensation to its boiler plant, all drips and condensation are dumped into the sewer. The hotel, by installing foreheaters, recovers the heat in this condensate by using it to preheat the house hot-water supply. In other words, all the available heat in a pound of steam entering the hotel is used.

In order to charge each department with that portion of the engine room's output used in the individual department, a complete set of recording flow instruments are used, as well as instruments showing the condition of the product used. On one board, Fig. 5, are placed indicating gages giving: *A*, the pressure in the heating main; *B*, the vacuum in the return lines; *C*,

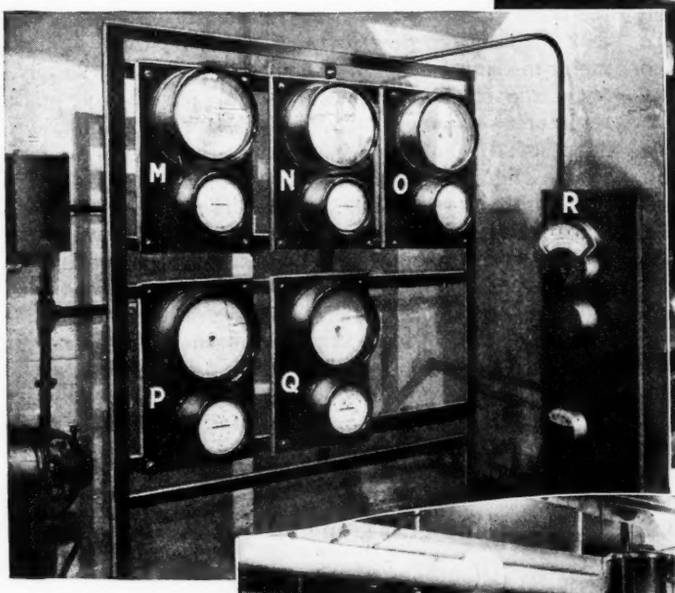


Fig. 1 — (Above) Instrument measuring steam flow to various departments

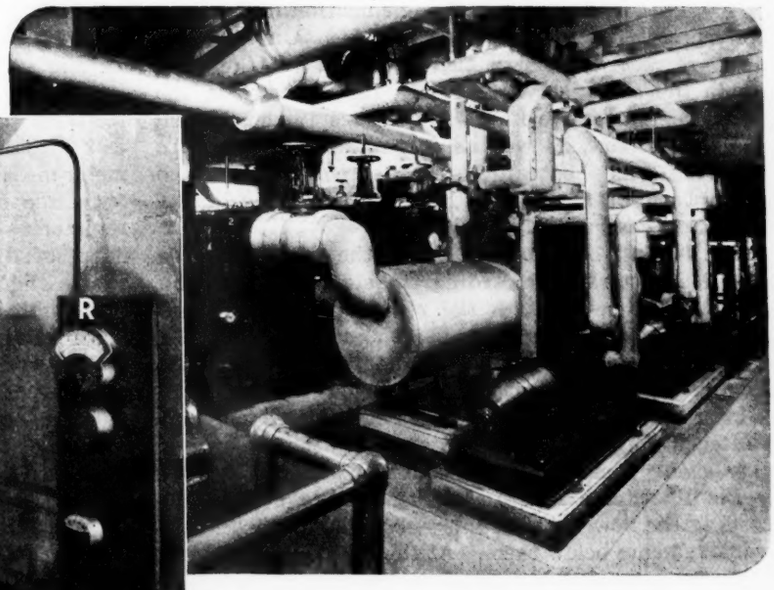


Fig. 2 — (Above) Heating condensation receivers and pumps

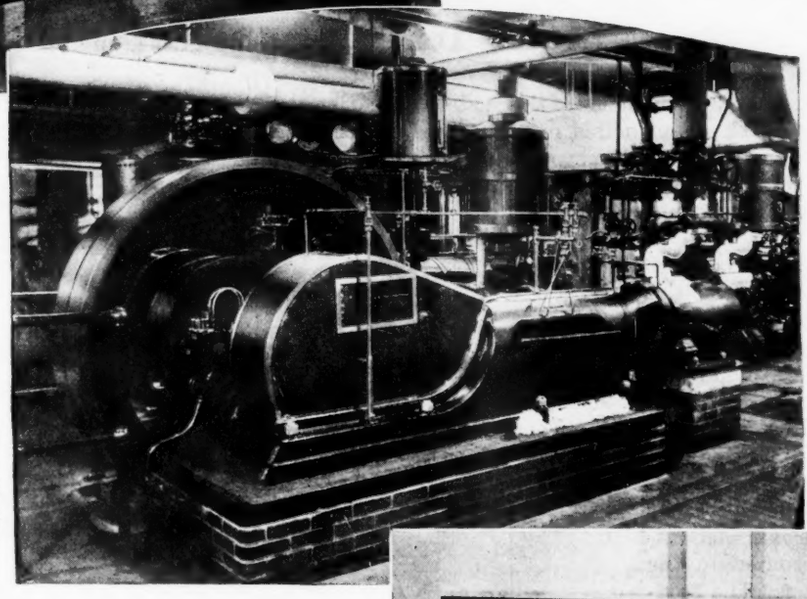
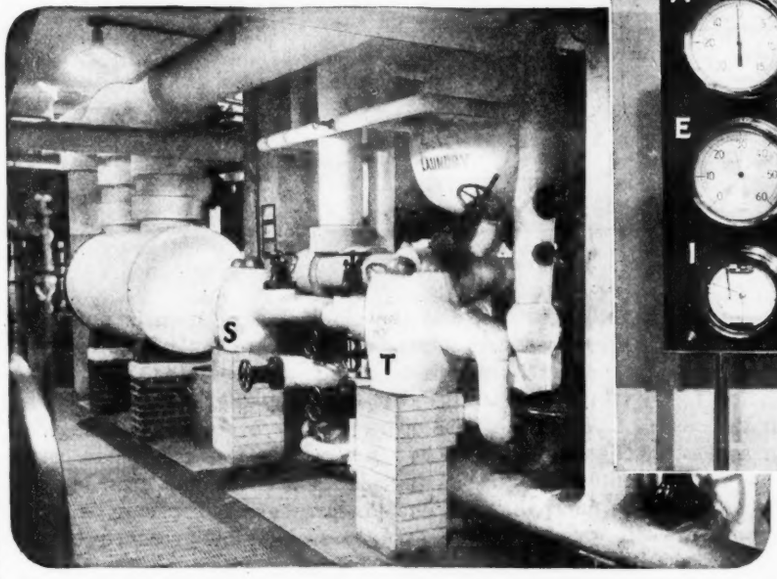


Fig. 3 — (Left) Double-acting high-speed compressor direct connected to a unaflow engine

Fig. 4 — (Below) Hot-water heaters and meters



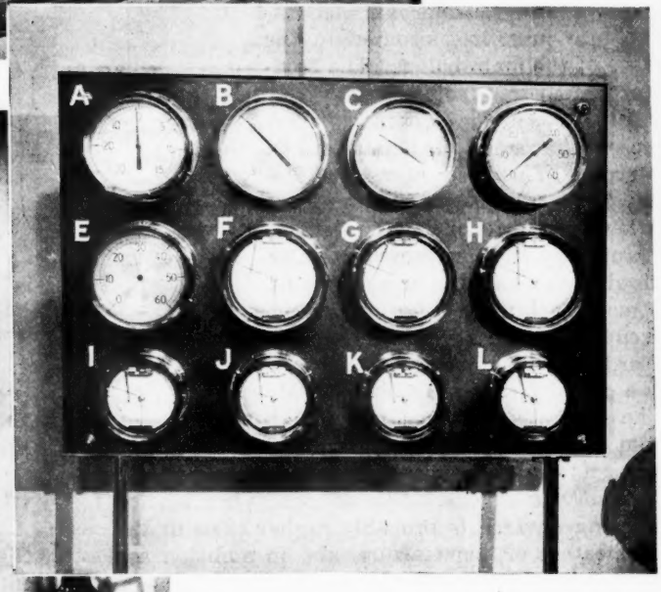


Fig. 5—(Above) Board carries pressure indicating instruments

temperature of the Johnson temperature-regulator system; *D*, the air pressure in the pneumatic-tube system; *E*, air pressure for the sewage ejectors. On the same board are recording instruments giving: *F*, the pressure in the steam-service line; *G*, the pressure in the laundry steam-service line; *H*, pressure in the kitchen steam-service line, as well as *I*, the water temperature in the kitchen heater; *J*, the temperature in the laundry heater; *K* and *L*, temperatures of the household water heaters.

On a second board, Fig. 1, are the dials of three steam-flow meters, *M* recording the steam going to the hot-water system through the reducing valves, *N* the steam to the engine generator sets and *O* the steam to the engines driving the ammonia compressors and to the refrigerating department pumps. Below these recording instruments are three integrating dials which total or integrate the values registered on the recording dials above. There is also a steam-flow meter *P* recording the live-steam flow to kitchen and a second, *Q*, recording the flow to the laundry, both having integrating instruments below them. At the right of this board is a recording flow meter showing the entire steam entering the building.

The water supply is measured in similar fashion. In Fig. 4 are shown the laundry and kitchen water heaters. The meter *S*, marked "laundry hot," totals the flow of cold water to the laundry water heater, and *T* totals the flow to the kitchen heater. A similar meter measures the flow to the house hot-water supply.

On the electrical switchboard are watt-hour meters registering the electric energy supplied the several floors of the hotel, the elevators, the lobby, the house pumps and other departments.

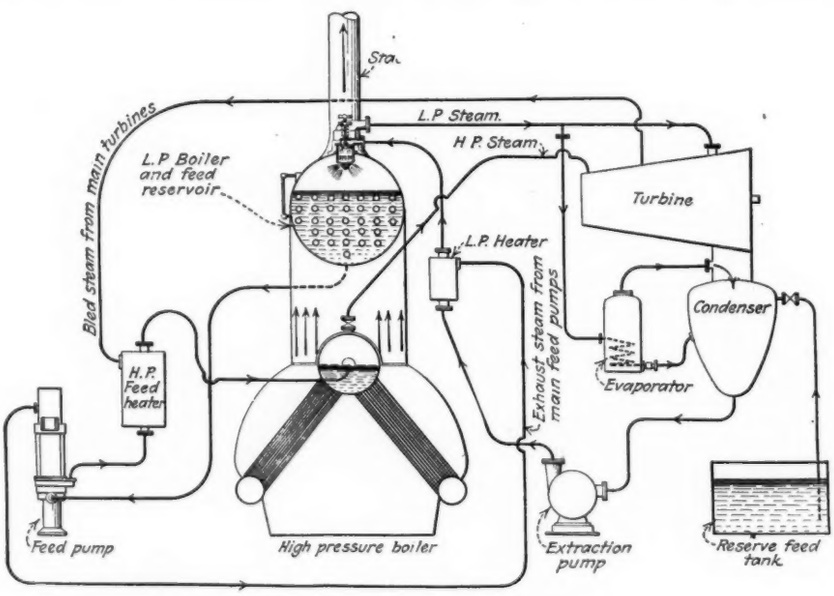
With the records made available through the use of these instruments the amount of electric, water and heating service supplied each department is easily computed. Chief Engineer S. Barnaby's force keeps a cost sheet upon which such charges are credited to the account of the engine room, and against the engineering department are charged all the items of expenses. The efficiency of the entire operating force is thereby kept at its peak, since the result obtained each day is a matter of record.

The Weir Heat Regeneration System

IN THE design and general arrangement of the modern power station the underlying principle must be the careful conservation of all heat in the system and its utilization at the maximum possible potential. Unnecessary drop of heat potential must be avoided at all points, and for this purpose, where heat exchanges take place, temperature gradients should be kept as small as possible. In practice this necessitates the application of regenerative processes wherever possible.

The Weir heat regeneration system is a new method of carrying out these principles as applied to the flue gases after leaving the main boilers.

The system, as shown in the diagram, consists of a low-pressure boiler operating at approximately atmospheric pressure, situated in the uptake of the main boiler. The feedwater is delivered from the condenser directly to this low-pressure boiler, which at the same time acts as a feed reservoir. The feed pump for the main boiler draws its supply from the low-pressure boiler. The steam generated by the low-pressure boiler is used in the low-pressure stages of the main turbine and for producing makeup feed in a low-pressure evaporator. It will be seen that in this way a closed feed system is achieved.



The Weir Regeneration System

The Weir system has a number of features that should cause it to be closely studied. The low-pressure boiler acts as a feed heater, a steam generator and a feed reservoir in one. The efficiency per square foot of heating surface is probably higher than in the case of preheaters or economizers, and in addition a closed deaërated feed system is obtained without the use of a deaërator.

The heat absorbing capacity of the low-pressure boiler is not limited to what can be taken up in feed heating. The main boiler can be forced without serious loss of efficiency, extra load being taken up by the low-pressure boiler. This latter boiler may be made of sufficient capacity to act as a steam accumulator to supply peak-load steam. The absorption of auxiliary exhaust steam in the feed water is made possible to the fullest extent, and the whole feed system is under low pressures. As a consequence corrosion in the feed system and boilers is to a measure obviated, which is of vital importance in any power plant.

While the developers of this system, G. & J. Weir, Glasgow, have made no installations, the plan seems applicable to existing plants where modernization is to be carried out. The low-pressure boiler can be added to existing boiler plants and a low-pressure turbine added to the engine-room equipment.

Field Current Adjustment of Synchronous Motors

TELLS what the effects of changing the field current will be upon the load current, power factor, efficiency and pull-out torque of a synchronous motor.

By QUENTIN GRAHAM
Power Engineering Department, Westinghouse Electric & Manufacturing Company

THE power factor at which a synchronous motor operates depends upon the field current and the load. For each load there is a definite field current that will give 100 per cent power factor. If the excitation is increased beyond this point, the motor will operate at a leading power factor and supply reactive kilovolt-amperes to the line and correct for lagging power factor of the system. For lower values of excitation the power factor of the motor will be lagging, which means that reactive kva. must be furnished by the power system to make up for the deficiency in motor excitation. Operating the motor under the latter conditions will tend to lower the power factor of any system that has a lagging power factor.

Synchronous motors are generally rated at either 100 per cent power factor or 80 per cent leading power factor. Occasionally, a motor is built for operation at some other power factor, although 100 per cent and 80 per cent are the standards. When motors are rated at 100 per cent power factor, they are known as unity power-factor motors.

Proper Exciting Current

The proper exciting current to use with a given motor under various conditions depends upon several factors. It will be necessary, therefore, to make certain assumptions in order to have a basis for discussing the subject. Let it be assumed first that the greatest possible amount of leading reactive kva., or corrective effect, is wanted at all times. To accomplish this it is necessary simply to excite the motor field coils with the highest current that it is capable of carrying. The leading kva. at any load will then be the maximum that it is possible to obtain. Normally, the field current that is used will be that which gives the rated power factor at full-load output. If the machine is liberally rated, it may be possible to operate with a higher field current, but this is a point that must be settled for each motor.

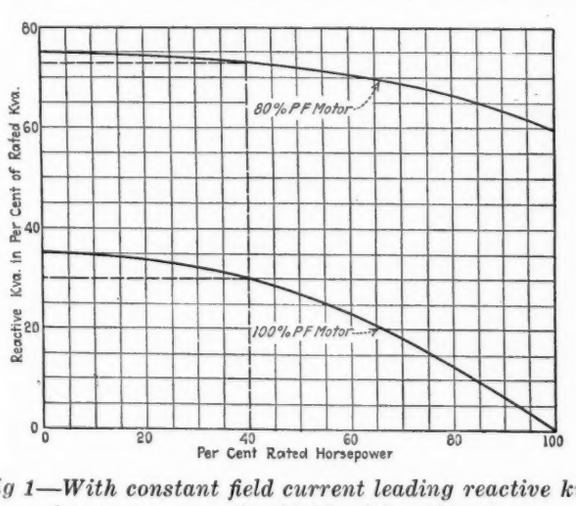


Fig 1—With constant field current leading reactive kva. increases as mechanical load is reduced on synchronous motor

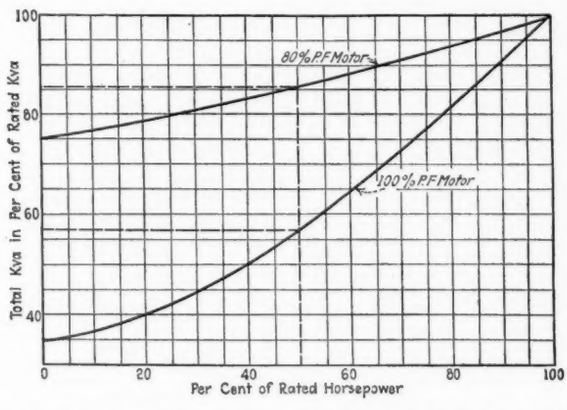


Fig. 2—Curves show how total kva. decreases as load is reduced on synchronous motor with constant field current

Condition of Constant Excitation

Under the condition of constant excitation at all loads the reactive kva. increases as the mechanical load is decreased. The total kva., which is the sum of the energy and the reactive components, decreases as the load is reduced. These relations are shown for typical cases by the curve in Figs. 1 and 2.

In Fig. 1, with the 100 per cent power-factor motor operating under full load, the reactive kva. is zero, or in other words the motor is operating at unity power factor. With 100 per cent rated load on the 80 per cent power-factor motor, it will be delivering a reactive kva. to the power system equal to about 60 per cent of the rated kva. of the motor. If the mechanical load is reduced on the motors to 40 per cent of rated horsepower, the reactive kva. delivered by the 100 per cent power-factor motor increases from zero to about 30 per cent of the motor's kva. rating, and on the 80 per cent power-factor motor the reactive kva. increases from 60 to about 73 per cent of the rated kva., as indicated by the dotted lines. If the load was removed from the motors entirely, the 100 per cent power-factor motor would deliver a leading kva. into the system equal to about 35 per cent, and the 80 per cent power-factor motor would deliver leading kva. into the system equal to about 75 per cent of the motor's rating in kva. The curves of Fig. 1 show how the reactive component of the load varies with a change in mechanical load on the motor and maintaining the field-current constant.

The curves, Fig. 2, show how the total kva. taken

from the line varies with a change of load on the motor. For example, at 100 per cent rated horsepower mechanical load on the motors and with the field current of each motor adjusted to give its rated power factor, each will take 100 per cent of its rated kva. At 50 per cent load the 100 per cent power-factor motor will be taking about 57 per cent rated kva., and the 80 per cent power-factor motor about 85 per cent rated kva. from the line, as indicated by the dotted line. Removing the mechanical load from the motor entirely, the 100 per cent power-factor machine will take 35 per cent and the 80 per cent power-factor motor 75 per cent rated kva. from the line. All the time that the load is being reduced, the power factor is decreasing in a leading direction.

Condition Where Efficiency Is Most Important

Let it be assumed that efficiency is of foremost importance and that the motor must be operated so as to obtain minimum losses at all loads. To accomplish this the field current must be varied so as to maintain 100 per cent power factor at all times. That is, the reactive kva. must be kept at zero. By operating at unity power factor, the loss in the armature winding due to reactive kva. is eliminated and the loss in the field is reduced.

To obtain unity power factor at any load, it is necessary only to vary the field current until the value that gives minimum current in the armature is found. The curves in Fig. 3 show the manner in which the armature current varies as the field current is changed. It will be noticed that there is a different curve for each

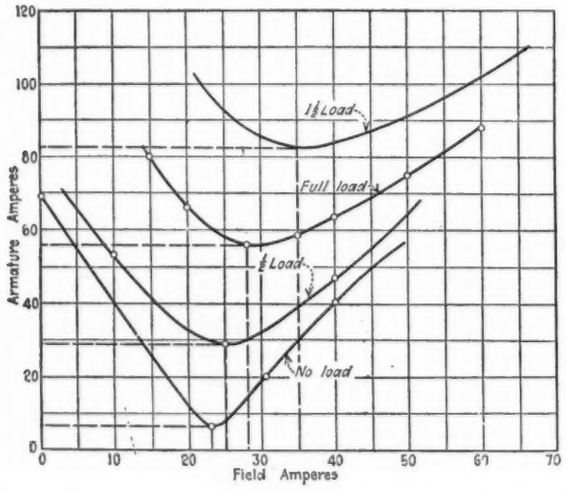


Fig. 3—Curves show how armature current of synchronous motor varies with a change in field current

load, but that in each case a minimum armature current can be found.

For example, Fig. 3, at no load the armature current will be at a minimum of about 6 amperes with a field current of 23 amperes, whereas at full load a minimum current of 56 amperes is obtained in the armature with 28 amperes in the field, as indicated by the dotted lines. Under these conditions the motor is operating at unity power factor. Either increasing or decreasing the field current will increase the armature current and decrease the power factor. At no load, if the field current is reduced to 10 amperes, the armature current will increase to 40 amperes and the power factor will be lagging. On the other hand, increasing the field current from 23 to 40 amperes will cause the armature current to increase from about 6 to 40 amperes and the power factor will be leading. With full mechanical load on the motor, if the field current is increased from 28 amperes to about 55, the armature current increases from 56 to about 80 amperes with a leading power factor. Decreasing the field current from 28 to about 15 amperes increases the armature current from 56 to 80 amperes, therefore, as previously pointed out, any change in the field current for any given load causes a change in the armature current.

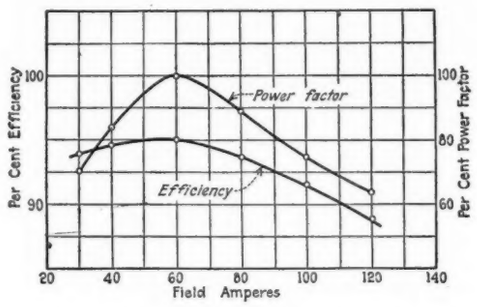


Fig. 4—Shows relation between power factor and efficiency

It should be noted that, in Fig. 3, the close relation between the field ampere values and the armature values is due to the field coils being excited with 110- or 220-volt direct-current and the armature being supplied from a high-voltage alternating-current circuit.

Effects of Field Adjustment on Efficiency

The effect of field-current adjustment on the efficiency of a typical motor is illustrated by the curve in Fig. 4. The power factor at each point is plotted also, and it will be seen that the maximum efficiency occurs when the power factor is 100 per cent, or when there are 60 amperes in the field coils.

If the field current is decreased to about 30 amperes, the power factor will decrease to about 70 per cent lagging and the efficiency will be reduced from 95 to about 94.5 per cent. Increasing the field current to 100 amperes decreases the power factor to about 77 per cent leading and the efficiency from 95 to 91.5 per cent. These curves were obtained by maintaining the horsepower load constant and varying the field current. The relation between these two quantities is shown by Fig. 5 for a particular motor. The maximum value of field current shown is that which would be obtained with the rheostat entirely out of the circuit and full exciter voltage applied to the field. While this amount of field current is considerably higher than the full-load field current and would result in a fairly high temperature rise, it could be used in an emergency to take care of high overloads. Under these conditions both the field and armature would be subjected to high temperatures if the overload and over-excitation were maintained for any considerable length of time. There may be occasions, however, when it is imperative that the motor be kept running under abnormal loads which can be carried only by raising the field current above the rated value.

From the curves it is evident that at 100 per cent

field current the motor will develop about 250 per cent full-load torque, or in other words the motor could carry about 250 per cent rated load. Increasing the load beyond this point would cause the machine to stall. With full exciter voltage applied to the field coils the exciting current increases to about 125 per cent normal and the pull-out torque of the motor increases to over 300 per cent full-load value. If the field current is reduced to about 75 per cent full-load value, the pull-

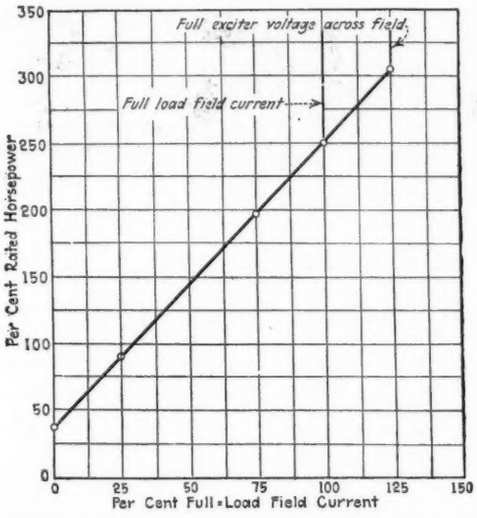


Fig. 5—Curve showing variation in pull-out torque with change in excitation

out torque is reduced to about 195 per cent normal; in other words, the motor will carry only about 195 per cent of its rated load, when it will pull out of step and stop.

Conclusions

To summarize, varying the field current of a synchronous motor affects its performance in three ways. An increase in field current gives: (1) An increase in leading kva.; (2) higher losses; (3) greater pull-out torque.

As a general rule the higher losses in the machine with over-excitation are more than offset by the gain in plant efficiency which results from the leading kva. supplied by the motor. Before over-excitation is used on any particular motor, it is well to look into the question of temperature and make sure that dangerous heating will not develop.

In no case should the field current be reduced below the value that gives 100 per cent power factor. Operation with the field under-excited results in the circulation of lagging kva., the lowering of the pull-out torque of the motor and the production of unnecessary losses and heating.

An excellent paint for the treatment of new and old concrete floors and one that is impervious to acids, oil, caustic substances, hot water, etc., may be formed by mixing one part by weight of kerosene with one part of cement. The mixture should be made by sifting the cement into the kerosene slowly and stirring vigorously. After thorough mixing has been secured, the liquid should be mixed with four parts of real coal tar, not oil tar. The paint may then be applied cold.

Testing Automatic Limit Stops on Electric Elevators

To test the automatic stops or limits on electric elevators stop the car at a level with the top floor and then throw the controller on the up position. If the upper limit is in proper order and properly set, the car will not move. The car should then be run downward approximately ten feet, then upward on the slowest speed, the controller held in that position, and the automatic or upper limit allowed to stop the car. If it stops level with the top floor or within 6 to 24 in. above it, and if there is still, say, two feet clearance between the car head beam and the overhead beams, and six inches or more clearance between the bottom of the counterweights and the ground, it may be considered that the upper limit is in satisfactory order.

It is desirable that the automatic or upper limit should be so set that when the car has traveled upward at full speed with no load, and the controller held on the "up" position, the floor of the car will not travel more than 12 in. above the top floor. There ought to be at least three feet clearance between the head beams of the car and the overhead beams, and at least 12 in. clearance between the bottom of the counterweight and the ground. The car should then be run downward and stopped level with the lowest landing. The control should then be thrown on the down position, and if the car does not start it should then be run upward approximately 10 ft., then run downward, with the control on the slowest speed, and the automatic or lower limit allowed to stop the car.

If the car floor stops level with the lowest floor, the car should again be run upward at least 10 feet, then run downward at full speed, the lever being held in that position, and the lower limit should stop the car floor at a level with the landing floor. When the car floor is level with the landing floor, there should be at least 12 in. clearance between the safety beam and the bumpers, and at least 18 in. clearance between the top of the counterweights and any obstruction above them. When these conditions exist, it may be assumed that the upper and lower limits are in satisfactory order as to adjustment; but all parts must later be examined for loose nuts, missing cotter pins, corroded parts, lack of oil, dirt, etc.

The clearance between the car counterweights and the drum counterweight clearance should be at least 14 in., although, if a condition is found where there is no more than six inches, it may be accepted; yet, there is danger of the two sets of counterweights striking when the car starts and stops, owing to the stretch in the cables at starting and stopping.

The following is a comparison between the heat contents of coal and fuel oil, based upon 19,000-B.t.u. oil, of 0.90 sp.gr., 7.5 lb. per gal. and 42 gal. per bbl.:

Coal, B.t.u. per Lb.	1 Lb. Oil = Lb. Coal	1 Ton Coal = Bbl. Oil
10,000	1.900	3.34
11,000	1.727	3.68
12,000	1.583	4.01
13,000	1.462	4.34
14,000	1.357	4.68
15,000	1.267	5.01

Do not expect your boiler to operate efficiently if you allow the tubes to become coated on the inside with scale and on the outside with soot.

Solid-Injection Engine with Novel Features

NEW Foos four-stroke-cycle oil engine has plain Diesel combustion chamber. No spray needles are used with the single oil pump. The reaction on the governor is very low, giving close speed regulation.

THE solid-ignition engine developed by the Foos Gas Engine Co. possesses a number of features of unusual interest. The frame is of box design as shown in Fig. 2. The cylinders are held to the frame by long studs passing through webs in the frame top. The liners are unusually long, as will be observed from the cross-section view.

Fig. 4 shows the form of the combustion space, which is essentially that of the Diesel engine. The spray is mounted on the cylinder axis in the same relation to the combustion chamber as a normal Diesel spray. The cylinder-head design is distinguished by the use of a telescope connection to the exhaust manifold which permits withdrawal of the head without dismantling inlet and exhaust pipe connections.

Dual valves are employed for both inlet and exhaust, and each pair of valves is operated by a parallel motion. The use of dual valves permits more than ordinary simplicity of the Diesel combustion chamber, since no pockets are required in the liner to clear the valves, as is the case where the larger single valve is employed. It is possible with this construction to carry the jacketing completely around the valve and spray housings, a desirable feature not always realized when larger single valves are used. The smaller dual valves give the further advantage that they do not require water cooling of the poppet. As it might be expressed, a 50-hp. cylinder is fitted with a pair of 25-hp. engine valves, thus the larger engine cylinder has all the freedom from valve trouble generally experienced with small cylinders.

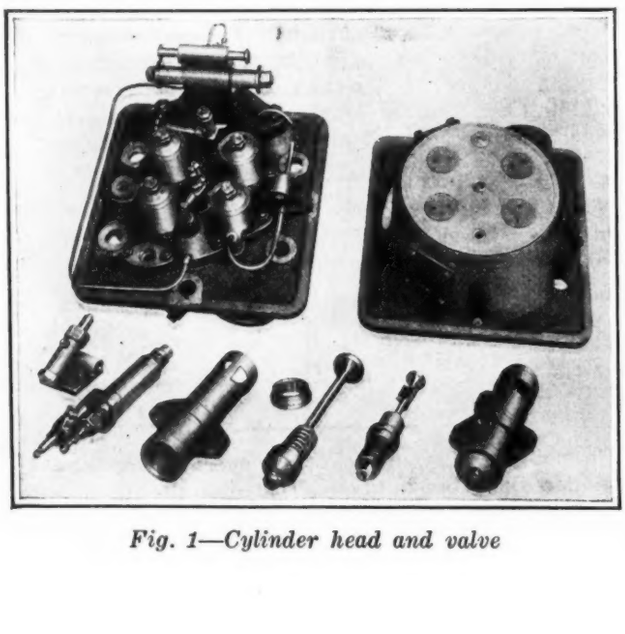


Fig. 1—Cylinder head and valve

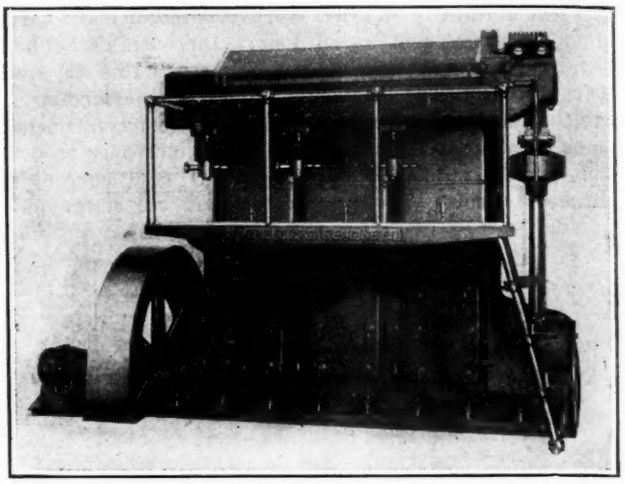


Fig. 2—Three-cylinder Foos engine

Automatic Measuring Desirable

It is the fuel pump and spray system that awaken special interest. There is general agreement as to the desirability of a pump system that will automatically measure the same quantity of fuel to each cylinder of an engine. Rather acute judgment is required to adjust the distribution of fuel when an engine is fitted with individual control mechanism for each fuel pump and cylinder. The indicator is, of course, the most refined aid to the operator, but it is not always available and, when used, its readings are subject to error due to the design and condition of the reducing motion. Furthermore, the indicator does not afford any clue as to the relative positions of the governor and control mechanism. With linkage adjusted too far in one direction in an attempt to secure balance of load, the engine may be incapable of carrying full load. With the linkage adjusted too far in the opposite direction, it may fail to control at no-load.

Other methods are proposed which avoid the use of the indicator. The commonest one requires the operator to run the engine, and if the governor assumes a different position for each individual cylinder, it is at once manifest that the cylinders are receiving different amounts of fuel and proper adjustments must be made. This is a process too tedious and delicate for many operators. An exhaust-gas pyrometer is sometimes used for balancing the load between cylinders. With every cylinder in good working condition it furnishes a satisfactory indication, but with one or more cylinders afterburning badly, it may indicate anything but the truth.

Everything considered, a fuel measuring and injecting mechanism that, in reasonably good condition, will function automatically is doubtless a great boon to both operator and owner. This has been realized for some years, and a number of devices have been suggested to serve the purpose. These devices have almost universally comprised a single pump for both measuring and injecting the fuel charge and some means of distribution. The single pump naturally had to be oper-

ated at more than camshaft speed in order to serve each cylinder in its turn.

The pioneer device was a distributor box placed in the fuel system having one lead from the fuel pump and as many leads on the opposite side as there are cylinders. Communication between the fuel-pump lead and the cylinder leads is established by means of a rotating disk having a single hole through its face which communicates in turn with each of the ports to which the cylinder leads are joined. This is clearly a very simple and effective device for the low pressure semi-Diesel engines, but at the 4,000 lb. injection pressure, normally used with the Diesel form of combustion to the layshaft. This cam has as many lobes as there are cylinders on the unit and, consequently, makes as many measuring or forcing movements as there are cycles in two engine revolutions. The cam motion is transmitted through a lever to the pump plunger *C*, which may be manipulated for priming purposes by the hand lever *D*, which is also used to elevate the plunger completely out of the range of the cam travel for stopping the engine. A floating lever operates the fuel-pump by pass, fulcruming on an eccentric shaft and deriving its motion by contact with the lever *F*. With the governor in a standing position there is sufficient play between the bypass valve and the plunger that

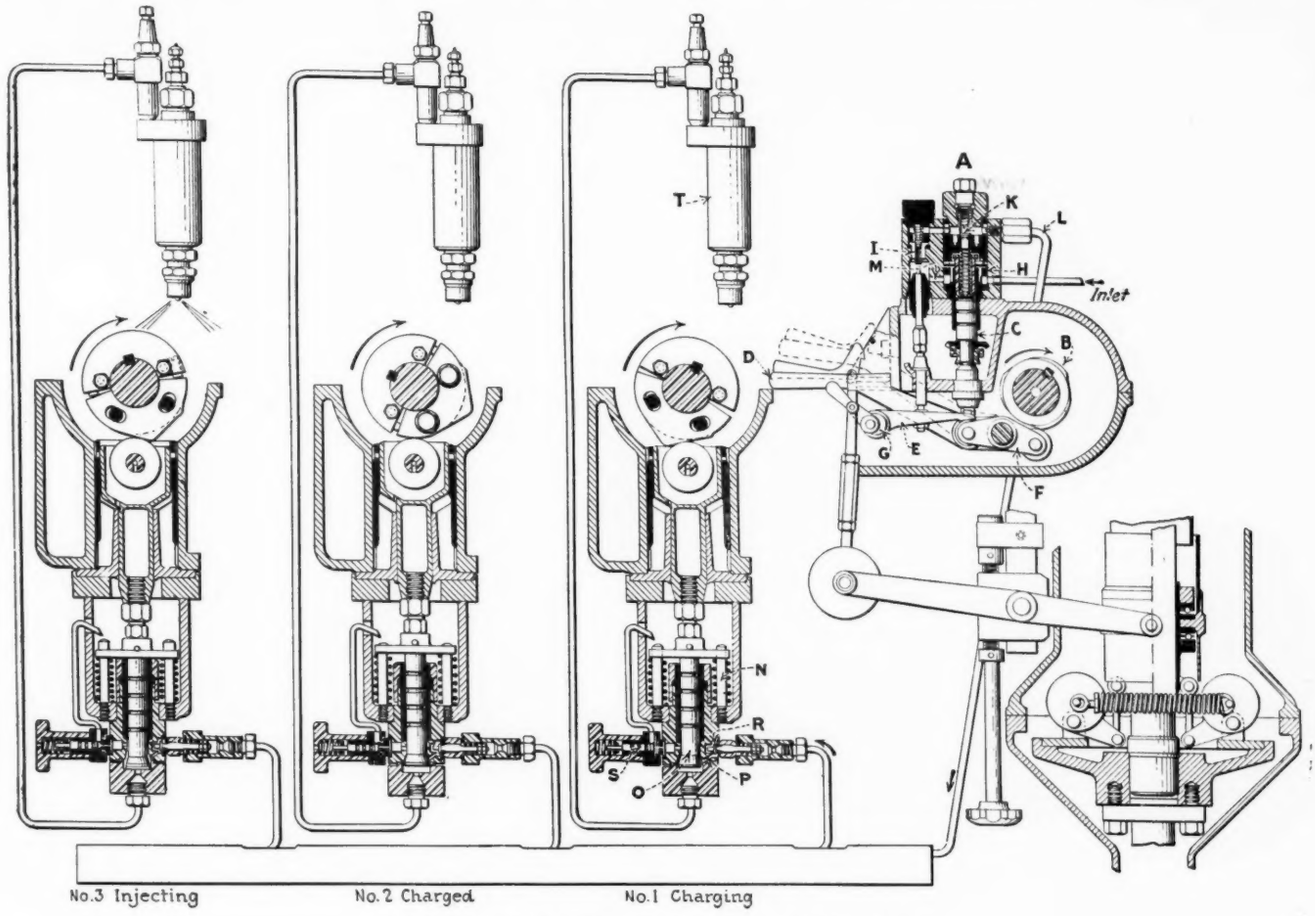


Fig. 3—Fuel pump and injection mechanism

chamber, a disk of only 2 in. diameter would carry an unba'anced load of 6 tons.

The Foos system avoids the faults outlined by novel but thoroughly developed means. The adjustments are of a purely mechanical nature and are made without the use of indicator or pyrometer. The general arrangement of fuel pumps and control is shown in Fig. 3, in which the detail is accurate, although the arrangement is distorted for the sake of clearness. The governor, which operates on the "measuring pump" only, is mounted in the housing which incloses the vertical intermediate shaft. The measuring pump itself stands just to the left of the force-feed lubricator shown at the upper right in Fig. 2. The injector pumps, which are changed by the measuring pump, suspend from the camshaft housing.

The assembled measuring pump *A* appearing at the upper right of Fig. 3 is operated by the cam *B* keyed operates it, to avoid any opening of the bypass, and all the fuel is delivered to the injector pump. Under operating conditions the governor moves outward to a suitable position and the eccentric *G* is turned, elevating the fulcrum of the lever *E* and decreasing the clearance between the bypass valve *T* and its plunger, causing fuel to be bypassed at some earlier point of the discharge stroke of the measuring pump.

This arrangement is a conventional one, and its merits lie in the application and detail design. The measuring pump operates under comparatively low pressure and therefore exerts little reaction upon the governor through the bypass and is little affected by leakage. There is only one connection to the governor and no opportunity for misadjusting the distribution of fuel.

The suction valve seat is formed on top of the measuring pump plunger guide *H*, which is of steel, case-

hardened and finished by grinding and lapping. The suction valve itself is of the disk type, encircling the plunger. A head on the plunger effects the valve closure during the return movement. The hardened and ground discharge valve *K* is mounted in a steel deck.

The fuel enters the measuring pump through the pipe marked "Inlet," passes up through the suction valve and is forced out through the discharge valve *K*, into the distributing manifold. The excess is cut out by the governor and returned by way of the bypass valve through the passage *M* to the suction side of the pump. The fuel is delivered to the manifold in waves

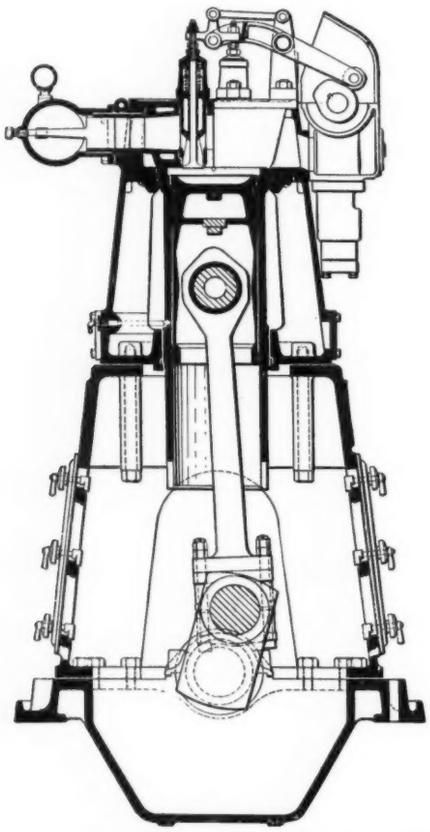


Fig. 4—Cross-section through the engine

of pressure so timed as to meet the charging movement of the injector pumps.

Fig. 3 shows the arrangement for a 3-cylinder engine. The delivery side of the injector pump cam is given the profile required to deliver the fuel at the proper spray velocity through a spring-loaded spray which will not open until the fuel pressure reaches 4,000 lb. per sq.in. The return side of the cam has a slower descent. Immediately after the injector pump cam permits the plunger to start its return movement under the influence of the springs *N*, the measuring pump starts delivering fuel into the manifold. To prevent this fuel from entering any of the three pumps at random, the injector-pump plunger is provided with a head, which is really a valve seat, at *O*. When the plunger has reached the upper end of its stroke, there is a clearance between the cam and the roller, and the plunger head, or distributing valve, has closed the opening *P*. It is then impossible for the measuring pump to force admission of more fuel to that injector-pump chamber.

The injector pumps shown in the figure are positioned at "Charging," "Charged" and "Injecting." The pump on the right is being charged, and the plunger is on the return stroke evacuating space in the pump chamber. The plunger head *O* is off its seat, allowing an opening through the passage *P* which admits fuel. The check valve *R* is forced open by the measuring pump, and a measured charge is deposited. Further movements of the cam, permitting the plunger *O* to seat, puts the pump in the position shown as "Charged" and closed against the further entry of fuel.

During the injecting movement the plunger head *P* must, of course, leave the seat, but as the spray pressure is 4,000 lb. per sq.in., the check *R* is firmly held down and no fuel can enter that particular pump from outside. Thus, as each lobe of the measuring pump cam *B* operates the measuring pump plunger through the discharge movement, some injector pump is making the receiving movement, while one particular plunger is returning, evacuating space in the pump chamber, and the admission port is open because the plunger head *O* is off the seat. No other pump can receive any fuel because those pumps that are not forcing, are sealed by the complete return and seating of the plunger or by the existence of the high pressure of injection in the pump serving the firing cylinder.

At *S* a spring-loaded pump relief valve is provided to relieve the pump and piping in case a spray should clog, owing to foreign matter left in the piping during assembly. The overflow from this relief valve furnishes visible means of determining which spray, if any, is clogged.

It will be noted that the injector pump does not have the conventional bypass. The sprays *T* are spring loaded and so designed that no fuel can pass the nozzle when the pressure falls to less than 3,500 lb. per sq.in., a function that is accurately carried out in operation. Thus the spray design obviates the necessity for the bypass so often thought essential to avoid dribble, and a considerable advantage is acquired in pump operation. The pumps must be moved at a rather rapid rate to maintain the pressure on the spray nozzle and yet must be suddenly stopped at the end of the stroke. Too often they are thrown clear of the cam and return with a blow under the influence of the springs. By carrying the fuel pressure right over the crest movement, the kinetic energy of the pump parts is effectively absorbed and the reversal of their movement takes place without any interval in which there is no contact between cam roller and cam.

In actual test with a great variety of fuels, including California crude of 14 Bé. gravity and with a variety of operators, the distribution of load has been shown to be within plus or minus 3 per cent as checked by the indicator and within 20 deg. F. grade as checked by the exhaust pyrometer.

The mixture of crushed firebrick and fireclay for the formation of mortar in the construction of furnace walls is a product preferred by many to that made from pure fireclay alone. In cases where fireclay is used alone, it will crack and crumble when subjected to heat and forms a very poor mortar. When mixed with crushed bats, the mortar forms an excellent bond with the brick and becomes as hard and durable as the brick itself.

How Shaft Whipping Is Produced

WHERE rotating elements revolve above the critical or natural vibrating speed, a slow oscillating movement is sometimes set up, the frequency being considerably below that of the normal operating speed. This has been termed "whipping," one cause of which has recently been studied with its relation to the design of rotating elements.

BEFORE taking up the problems in connection with shaft whipping as worked out in the Research Laboratory of the General Electric Co., a review of some simple forms of shaft vibration may prove useful. In Fig. 1 a shaft previously at rest is set in straight-line vibration by a single forced deflection or impulse. On releasing the rope, the shaft would tend to straighten itself, the restoring force then setting up natural vibration in a single plane. The center of the pulley would vibrate in a straight line, provided the shaft gave way equally at each end. For convenience, therefore, this will be referred to as straight-line vibration, the travel of the center of the pulley being indicated by a straight dotted line at, let us say, 400 complete vibrations per minute. It is apparent also, that if the shaft were suspended from a thrust bearing at the upper end, the pulley center would move in the arc of a circle. Such a condition, however, is not here assumed, but instead, the shaft is considered as slipping through each bearing an equal amount in order to keep conditions as simple as possible.

In Fig. 2 is shown the effect of a single impulse of the same kind given to a shaft revolving at high speed, such as 2,000 r.p.m. On being released it would also vibrate in the same way as in Fig. 1, representing straight-line vibration at its natural period of 400 vibrations per minute. In spite of the fact that the shaft is rotating 2,000 r.p.m., the restoring force due to its elasticity would have the same effect as before in setting up natural or "critical" vibration.

Movement in an elliptical path such as in Fig. 3, may be produced either in a non-rotating shaft or in one moving at high speed. While the restoring force on releasing the rope at the left would allow straight-line vibration, force is also applied perpendicular to this movement, so that a displacement away from the straight-line center is produced. As a result of the two impulses at right angles, a vibration in the form of an elliptical or circular path takes place. This would also be at the natural period of 400 complete vibrations per minute.

Oscillation at the natural vibrating frequency about an elliptical path or through a plane when the shaft rotates at a speed different from that of natural vibration would be called "shaft whipping." Here the shaft moves either through or around its center as occupied when at rest. The action, as illustrated, is produced by forced shaft displacements, but other causes may also set up this, as described herein.

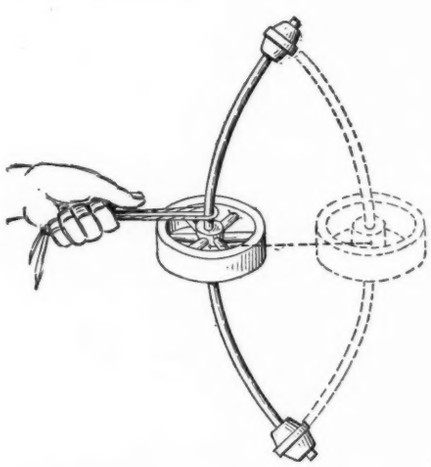


Fig. 1—Non-rotating shaft given straight-line vibration by single displacement

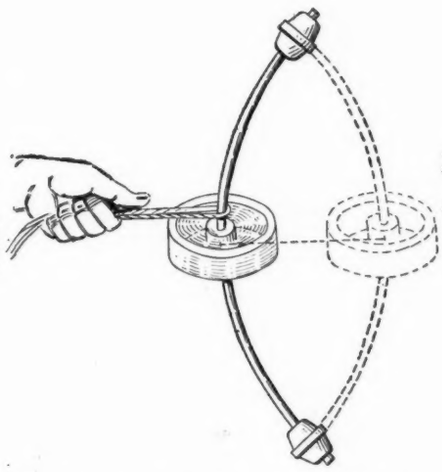


Fig. 2—Spinning shaft set in straight-line vibration by single displacement

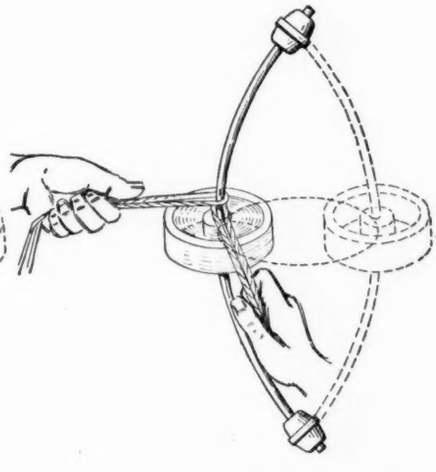


Fig. 3—Elliptical or circular vibration from two displacements in different directions

Shaft vibration also may take other forms, such as that where the shaft center moves in a spiral path or in closed curves of different character from those described. Motions of this kind, however, are not vitally related to the subject at hand and therefore are not here considered.

Shaft whipping has been noticed to a very slight extent in small rotating machines. This phenomenon, however, became of serious magnitude in connection with large centrifugal air compressors. Whipping was sometimes of a gentle and inoffensive character, while in other instances it developed into more violent vibration, the causes of which were not understood.

The whipping motion appeared to be a slow shifting of the shaft, or vibration of comparatively low frequency. Compressors with rotors that had a natural period of vibration around 1,000 r.p.m., would not whip when rotating at speeds below 2,500 r.p.m. The manifestations were variable in character, so that it could not be predicted accurately from the known operating conditions when whipping would occur. Refinement of balance did not reduce this vibration, and the tendency appeared to depend upon conditions of temperature and humidity of the air. The steadiness of the blowing action was an important factor. A compressor working against high furnace pressure near the pressure breakdown point of the machine was most likely to whip, but did not always do so.

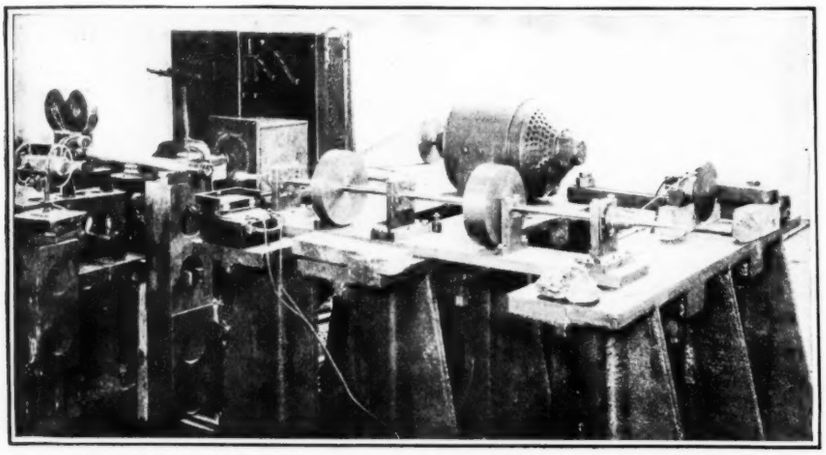


Fig. 4—Model with shaft extended at right for photographing the pointed end

Whipping could be influenced by the alignment conditions. It was customary to adjust self-aligning bearings with great care, and special precautions were taken to prevent distortion of the alignment of the machine by pipes or otherwise. When whipping occurred, it could sometimes be stopped temporarily by driving wedges at one point or another under the compressor foot to change slightly the alignment. It was known that the fit of the impeller hubs and the packing sleeves on the shaft had much to do with the whipping tendencies and that any long, tightly gripping sleeve was sure to produce whipping.

The problems undertaken by the Research Laboratory of the General Electric Co. were to find the causes and their mechanical action in producing the whipping movement observed in practice, the laws that governed this vibration mathematically, and what remedies were to be applied. It will be recalled in the early development of the steam turbine De Laval was confronted with vibration trouble. As a result of his efforts the important part that the natural vibrating speed plays in obtaining good high-speed operation was finally demonstrated. Theoretical discussions of the fundamental or critical speed as well as those of higher frequencies that resulted, made their calculation a convenient matter.

The study of vibration in turbine wheels or disks has been carried on both here and abroad, one of the most valuable contributions to the subject being the remarkably complete paper by the late Wilfred Campbell, an abstract of which appeared in the July 15, 1924, issue of *Power*. Critical vibration here again was brought into prominence.

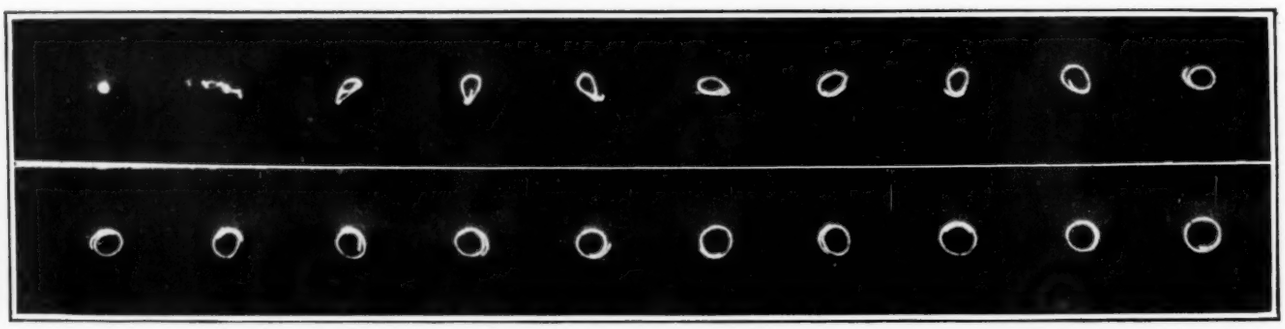


Fig. 5—Movements of pointed shaft end in building up whipping oscillation

Fig. 6—Forced compressor shaft displacements (large dots) produce no whipping

The investigation of whipping, however, in papers recently published in the *General Electric Review* by B. L. Newkirk and A. L. Kimball, Jr. revealed that, though closely allied with critical vibration, whipping

of the kind studied was due to a type of mechanical friction, followed the usual laws of undamped or free vibration, and could be remedied in a simple, inexpensive and positive manner.

The frequency of the whipping movement was measured in two ways: One, by means of electromagnets embedded near the shaft of a whipping rotor, so that oscillations of the shaft could be measured by the aid of an oscillograph, and another, by photographing the movement of the end of the shaft extended through an outboard bearing, during the whipping motion. An experimental model appears in Fig. 4.

By the first method the frequency with which the shaft approached and receded from the coil could be measured. Photographs during the whipping motion, both of a model, Fig. 5, and also those taken in compressors served to check the oscillograph measurements, with the result that shaft whipping was found to occur at the frequency of natural vibration. The shape of the path that the shaft end traveled, although approaching a thin ellipse or straight line in the compressor, was nearly circular in the model, showing that movement took place symmetrically around the center of the shaft as at rest and in the general direction of rotation.

Investigation revealed that the whipping motion

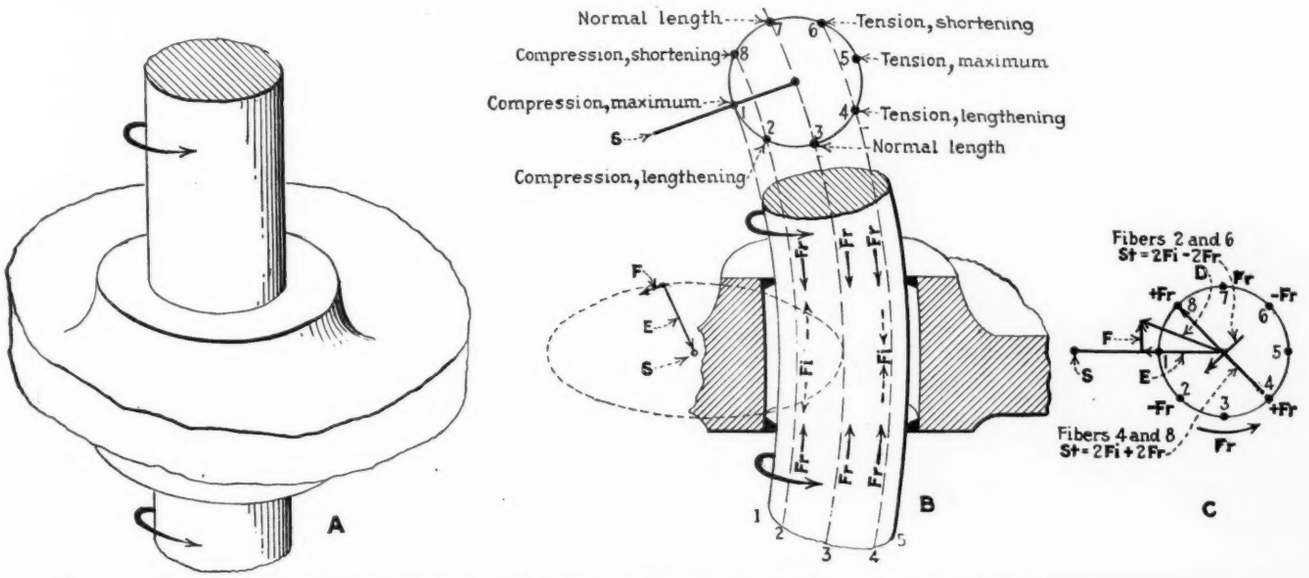


Fig. 7—High-speed vertical shaft at A vibrates in ellipse as at B when given a single displacement, resulting from binding of the collar, setting up reactions as at C

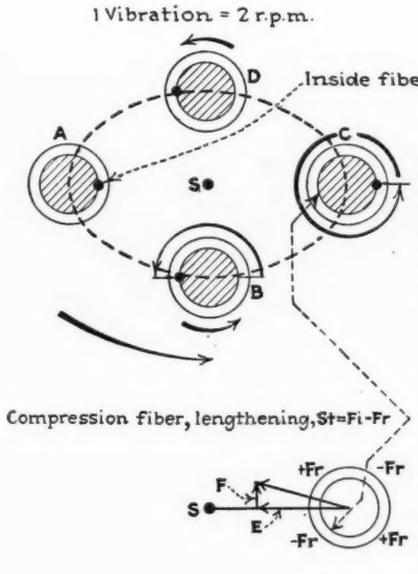


Fig. 8—Shortening and lengthening of the fibers builds up whipping in shaft above critical speed in the general direction of shaft rotation

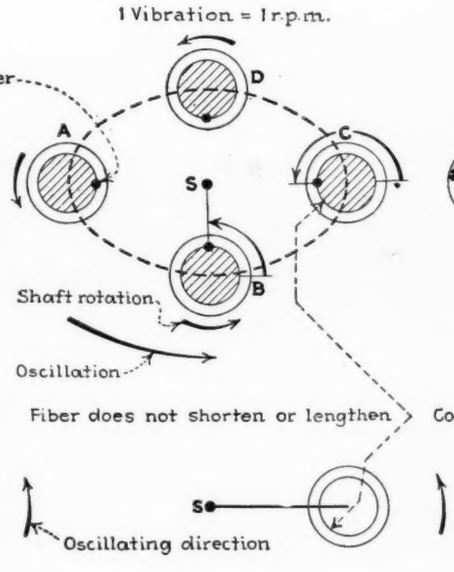


Fig. 9—Fibers do not contract or lengthen when shaft revolves at critical speed, and there is no collar friction to help build up an oscillating movement

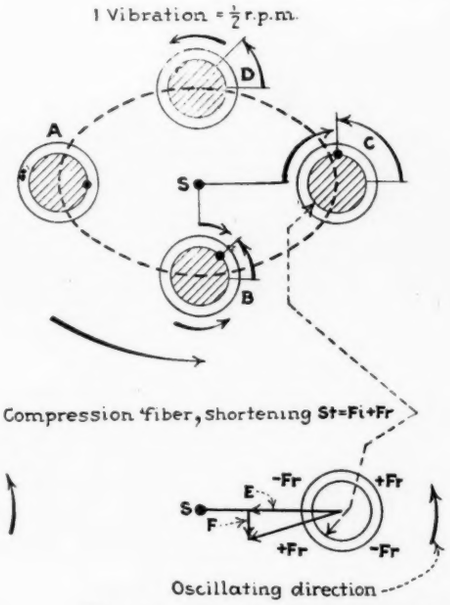


Fig. 10—Shortening and lengthening of fibers in shaft below critical speed tend to oppose elliptical vibration in the direction of shaft rotation

which, if started by a slight jar, would then build up of itself to a large amplitude, as shown in Fig. 5, was due essentially to the cramping action of hubs or collars which were pressed or shrunk on the shaft. Fig. 6 indicates an air-compressor shaft that would not whip in spite of forced deflections.

A model, similar to Fig. 4 was fitted with a sleeve that could be made to grip the shaft by tightening an adjusting nut. With heavy binding, whipping would build up from the slightest irregularity or jar into serious disturbances. Without this hub pressure, whipping would die down of itself, no matter how violently it had been set up from outside impulses. One fact of importance was that this vibration did die down of itself when the shaft rotated at critical speed or below it.

The mechanical action of gripping members in setting up oscillation of high-speed shafts is shown in Fig. 7. A vertical shaft at *A* with a tightly gripping hub or collar would not whip ordinarily unless it were displaced from the vertical position. If an appreciable deflection is introduced, as indicated at *B*, the friction of the collar would then set up forces tending to produce oscillation in an elliptical path, which would correspond to whipping.

TABLE OF EFFECTIVE FORCES TENDING TO STRAIGHTEN THE SHAFT FOR EACH FIBER AS IN FIG. 7

No. of Fiber	Effective Force	Representative Formula
1	Fiber stress only	St = Fi
2	Fiber stress minus friction	St = Fi — Fr
3	Friction stress only	St = Fr
4	Fiber stress plus friction	St = Fi + Fr
5	Fiber stress only	St = Fi
6	Fiber stress minus friction	St = Fi — Fr
7	Friction stress only	St = Fr
8	Fiber stress plus friction	St = Fi + Fr

It will be seen that fiber No. 1, shown above at *B*, is in the maximum compression and is moving toward the right. Fiber No. 2, in less compression, is rapidly elongating owing to the high speed of rotation and exerts a certain force tending to straighten the shaft.

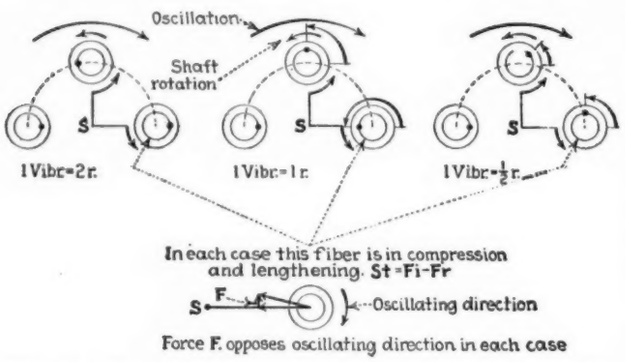


Fig. 11—Vibration in a direction against shaft rotation is opposed by collar frictional forces

However, this fiber must slip through the collar slightly as it elongates, and the friction due to sliding through each end of the collar tends to reduce the effective straightening force, as indicated by arrows along the shaft. The restricting action of the collar builds up a force that opposes the straightening action of this fiber.

Fiber No. 3 is at its normal length, but its length is changing most rapidly. At this point slipping through the collar is at the maximum rate and friction is most effective. Friction acts oppositely on fiber No. 7. Fibers No. 3 and No. 7 tend to bend or displace the shaft in the direction of the arrow *F* at *C*.

Fiber No. 4 is longer than normal and therefore in tension. As it is lengthening, the hub friction tends to build up the tension further, thus actually increasing the straightening force. The effective effort of each fiber deduced in this way is summed up in the table.

As is shown also in Fig. 7 at *C*, the combined straightening force of Fibers 2 and 6 is less than that of Fibers 4 and 8. The result is an arrow *D*, tending to produce oscillation in an elliptical or circular path. This has a component, *E*, in the direction of the restoring force, which would produce straight-line vibration, and also another at *F*, at right angles to this, which would tend to produce elliptical oscillation. It should be noted that the elliptical movement thus excited would be in the general direction of shaft rotation.

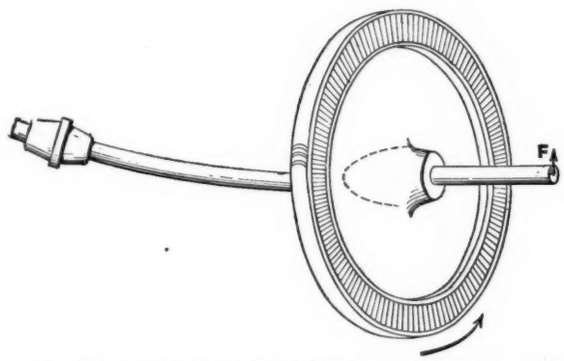


Fig. 12—Tendency to whip in horizontal shaft is around non-rotating axis

The explanation of why whipping will die out if mechanically produced in the direction of rotation at critical speed or below, is given in Figs. 8, 9 and 10. At the left, Fig. 8, is the same condition as in Fig. 7, namely, a vertical shaft with a tight collar operating considerably above its critical speed and forcibly deflected. It is known that the result of friction in this case will induce an elliptical path of vibration in the general direction of rotation.

In Fig. 9, however, the vertical shaft is supposed to be revolving exactly at critical speed. After being forcibly deflected to the right and made to revolve in an ellipse, there will be found no tendency, due to friction, to increase this oscillation. The inside fiber at *A* will make one-quarter of a revolution to the quarter position *B* and still represent the inside fiber, or that of maximum deflection.

At one-half revolution *C* around the ellipse the shaft will also make one-half of a revolution from *A*, keeping the inside fiber in the same relative position. Fibers therefore, will neither move to the right nor to the left, nor up nor down, with regard to the center of symmetry *S*. As the fibers will not shorten or lengthen, due to both shaft rotation and oscillation, frictional effects will not take place as in Fig. 8, and there will be no tendency to compel elliptical vibration.

In Fig. 10 the shaft operates or revolves considerably lower than at its natural period of vibration (in this case one-half as fast) and is forcibly given an elliptical path as shown. In one-half the vibration from *A* to *C* the shaft makes only one-quarter of a revolution. It is thus behind its original relative position, having moved against the motion of whipping in the direction of the

internal arrow at *C*. This is opposite to the movement in Fig. 8. The forces due to collar friction will therefore be in the opposite direction, as described in Fig. 10. Unbalanced forces will consequently tend to oppose the elliptical movement begun in the general direction of rotation. They will therefore reduce the original ellipse to a spiral of decreasing radius.

Assume whirling in opposite sense and rotation at any speed. It will be found that the force developed is opposed in direction to the whirling.

On the foregoing figures the oscillation or vibration or whirling has been considered as being set up in the same general direction as shaft rotation. If, however, oscillation is set up in a general direction opposite to shaft rotation, the effect of collar friction will be to dampen it out as at Fig. 11.

The fiber corresponding to No. 2, Fig. 7, will have the same position with respect to the vibration, as in Fig. 10, with clockwise oscillation. This fiber will in each case be in compression and will be lengthening. Forces due to friction will be in the same direction as for Fig. 8, so that they will oppose the direction of oscillation and cause it to die out.

When the shaft is horizontal, Fig. 12, the conditions do not differ greatly from those just discussed. The weight deflects the rotor when it is not running, into a certain elastic deflection curve. The shaft runs in

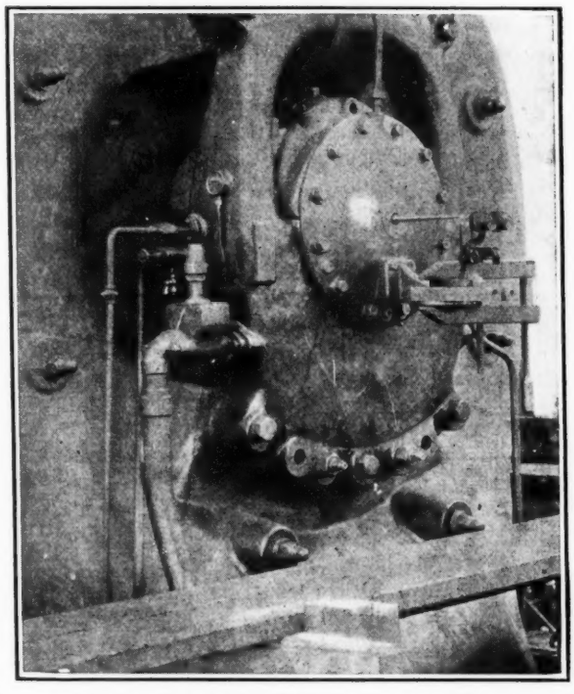


Fig. 13—Shaft extended through end bearing of compressor for photographing the motion at its end

this deflection curve when it is running true. When whipping occurs, the deflections vary from this elastic curve about as they would from a straight line if the shaft were vertical.

Fig. 14 at *A* shows a model shaft on which a hub was shrunk with a heavy fit. This is so constructed that shaft deflection did not produce friction between the hub and the metal on which it contacted. Whipping in this instance could not be built up under any experimental circumstances, and internal friction of the fibers of the shaft, one against another, was insufficient to produce whipping. This proved that friction due to a tight fit was the true cause of this action in practice.

Whipping in air compressors or experimental models was found to be readily eliminated by introducing flexibility between the bearing and its support. A very small amount of elasticity would suffice for dampening

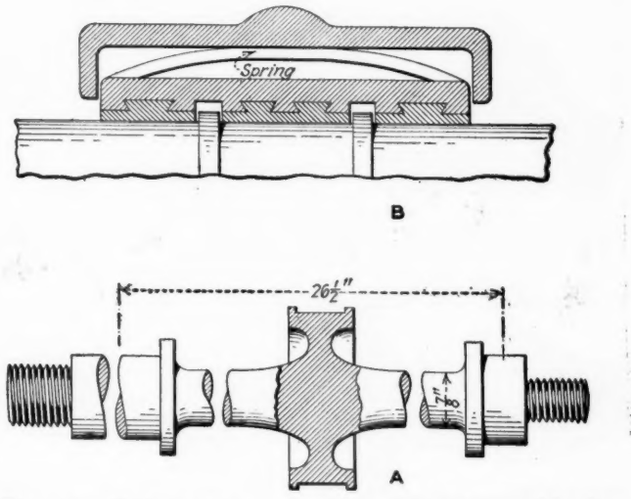


Fig. 14—Hub pressure (A) does not cause whipping. Spring support (B) prevents whipping action

the whipping action. The application of springs somewhat as indicated at *B*, Fig. 14, would allow a flexible bearing, and the total deflection due to the rotor would be 0.005 to 0.010 in. Fig. 6 shows pictures of the shaft extension on an air compressor with one flexibly supported bearing on which whipping could not be built up in spite of severe external disturbances. A compressor shaft, as extended for photographing, appears in Fig. 13.

It was clear that for a condition of stable whipping, the usual equations for undamped or free vibration held good. An analysis of such oscillation with friction of the shaft fibers against each other as a cause, accounted mathematically for setting up the motion, wherein the shaft center traveled from its rest position in a spiral path as the amplitude was increased. A model shaft built of long thin elements binding against each other with appreciable friction, demonstrated such conditions in actual fact.

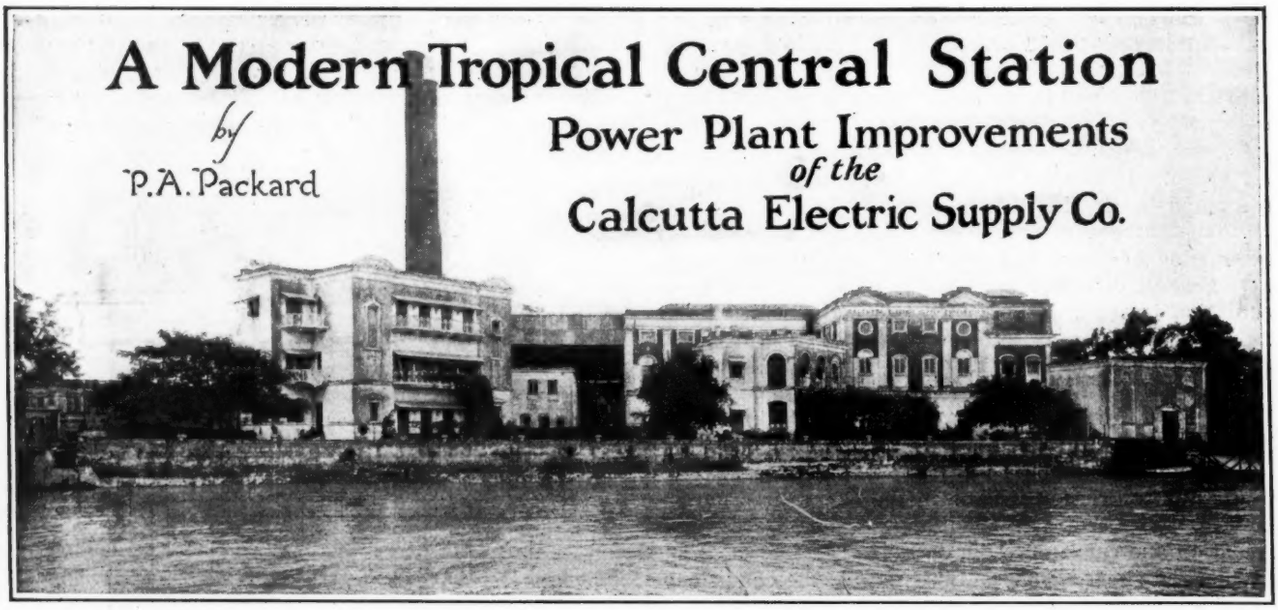
Boiler blowoff lines should be constructed as straight as possible, with long-radius bends instead of elbows wherever practicable; they should be properly anchored with liberal allowance for expansion. Blowoff lines should be kept up out of wet ditches, where rapid corrosion and rusting will soon destroy them. Such lines, when new, should be thoroughly cleaned off on the outside, a coat of red lead spread on, and after this has dried completely, a coat of bitumastic paint should be applied. In cases where conditions are severe, two coats of the bitumastic paint should be put on. The lines should be scraped and new coats of paint applied at least once every six months.

A good pipe joint cement may be made of a mixture of cement and old lubricating oil, mixed to a thick consistency.

A Modern Tropical Central Station

Power Plant Improvements of the Calcutta Electric Supply Co.

by P. A. Packard



EVERY schoolboy, at the mention of Calcutta, India, connects its importance with the Black Hole, where during the Sepoy rebellion a mass of English men and women met a miserable death. However, this great city with a population of one and one-half million, owes its position to a more pleasing fact—it is one of the most extensive trade centers of the East. The need of electricity in an American home is moderate compared with the requirements of a tropical life, and as the city developed it became apparent that if it was to maintain its supremacy as the great mart of the East, the old fashioned Punkah, or swinging curtain, kept in motion by a drowsy coolie, must give way to the more efficient electric fan. Likewise the mazda light must take the place of the smoky oil lamp and tallow candle. To bring about this new era, the Calcutta Electric Supply Corporation was granted a license in 1896. The united station consisted of Willans engines, Crompton dynamos and water-tube boilers, and was erected in Emambagh Lane in 1899. For the following ten years the rapidly growing demand forced the construction of three more plants in different parts of the city. The use of several small lighting plants was not economical, and in 1909 one main generating station of 3,000 kw. capacity was erected at Cossipore, outside of the city upon the Hooghly River. The power was to run through underground cables at 30,000 volts to substations in the city, where rotary converters transfer it to direct current.

Plant Buildings

The plant is shown in the headpiece along with other buildings on the station plot. In the left foreground are the quarters for the single and married European supervisors. The building in the center of the picture immediately at the water edge is a new circulating-water pumphouse, while at the right but somewhat in the background is the old pumping plant.

The alluvial formation of all the ground in this section of India, situated on the great delta mouth of the Ganges, for which the Hooghly is the largest drain, requires utmost care and consideration in the laying down of heavy buildings, particularly those with weighty generating equipment and high and heavy stacks. Accordingly, a double-reinforced concrete mat about four feet in thickness was laid down strong enough to support without fracture any heavy weight imposed thereon.

While one is prone to assume that a tropic power plant must be equipped with the most primitive of apparatus, the new Calcutta plant contains practically all the accessories found in a modern American central station.

The original layout was made up of 3,000-kw. Swiss make turbines and English water-tube boilers. Expansion of the demand was so rapid that in 1923 it was deemed advisable to install another 6,000-kw. and two 15,000-kw. turbo-generator units and four water-tube boilers. The inclined-tube boilers are of large capacity, having 11,160 sq.ft. of heating surface each and are fitted with two types of underfeed stokers. The boiler room has a full complement of pressure gages, steam-flow meters, CO_2 indicators, flue-gas temperature indicators, draft-gas and feed-water meters, etc. The controls for both forced- and induced-draft fan motors are brought to the firing floor in close proximity to the damper- and stoker-motor controls, so that the boiler-room supervisor has everything at his elbow. A general oversight of the plant is kept by a senior supervisor in whose office are placed electric recording steam-flow and other meters.

Modern Coal Machinery Used

The method of handling the coal is of particular interest. The system is designed so as to take rail-borne coal and deliver it as quickly as possible to the overhead bunkers of the new or old boiler houses, or to load coal to, or take it from, a storage pile by means of grab buckets on a telpherage system of overhead transportation. Loaded cars of 25 tons net weight come in on a trestle and are passed over the weigh bridge and into the tippler, which lifts a car bodily and drops the coal into a bunker. The coal feeds from here through either of two crushers and drops into the

grabbing bin, after which the telpher carriages with their grab buckets transport the coal to the bunkers of the new and old boiler houses.

Tidewater works its way up the channel during the low river flowage period, which extends from February to July, and unusual precaution is required to prevent salt getting into boiler-feed supply. An evaporator of 10-ton hourly capacity when working in double effect, takes care of the necessary makeup supply.

The motor-driven feed pumps are arranged for flexibility of operation to feed either the new or the old boiler houses or a combination of the two, two pumps being sufficient to handle any load requirement. The feed pumps in the old station are steam driven and may act as temporary stand-bys in case of failure of electric current.

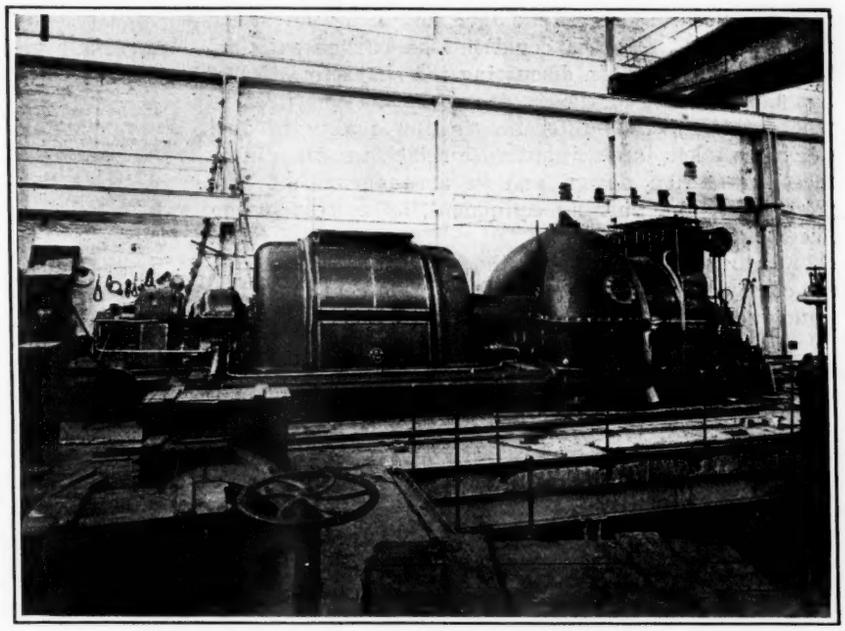
The turbines are designed for steam at 175 lb. gage with a total temperature of 700 deg. F. and a vacuum of 28 in. Their rated load is the most economical point on the steam-consumption curve, but their maximum continuous rating is considerably higher. Each is fitted with a main and auxiliary oil-supply pump, and the oil pressure is interlocked with the turbine stop valves so that it is impossible to start the machine without previously putting the oil pressure on the bearings. Electric alarms warn the operators of failure of the oil pressure. The main bearings are equipped with thermometers and visible discharge openings for the oil. Oil filters, settling tanks and coolers are arranged to work individually or in groups. The governors are oil controlled and are fitted with hand- or motor-operated movement to facilitate load interchange and synchronizing. Each unit is fitted with bleeders to maintain a proper heat balance.

While the older plant had the condensers fitted with Edwards air pumps, the new installations have steam ejectors and motor-driven condensate pumps in duplicate. The return water passes a closed heater and a degassing plant, where a reagent extracts any traces of oxygen or air. The old circulating-water system is on the Goit principle. On the shore were erected vertical pumps, each equipped with its own hinged suction pipe brought in from a screened enclosure floated on the water. The pump discharges empty into a canal which passes along the side of the station, and from which other pumps push the water through the condensers. The circulating-water system for the new portion of the station is supplied through a 5-in. pipe from vertical motor-driven pumps in caissons on the river. The water is forced through the condensers and back to a sealed outfall through a 45-in. main. When the tides are running at the average height, the siphon principle assists the pumps in their work. The overflow is drowned behind a weir, and vacuum pumps on the roof of the station keep the system air free.

The switchboard and gallery are arranged in sections for the control of the 6,000-volt, the 400-volt a.c. station and the d.c. auxiliary circuits. There are also a few outgoing direct-current feeders. The 6,000-volt switch gear is of the cellular construction type with each machine or feeder phase in a separate compartment. Oil switches are motor operated from the control gallery. The busbars are split up into three groups with reactances between each group. Any machine or any feeder normally works on its own group, or in case of emergency by switching on to a second group. The turbine control panels are fitted with field resistance handwheel, voltage regulator, governor-control switch, turbine-signaling telegraph and temperature indicators, besides the usual array of indicating meters.

The supply of power for auxiliaries is taken directly from the 6,000-volt busbars to three 700-kva. single-phase transformers. The secondaries connect through distribution boxes and switches to the following equipment: Condensate-pump motors, air-filter motors, circulating-water pump motors, forced- and induced-draft fans, coal crushers, crane and capstans.

There is a "missing link" in the way of a 1,000-kw. motor-generator set. It can take either the low-tension alternating current from the transformers and supply direct current or in the event of a breakdown on transformers it can take direct current from the direct-current buses and supply alternating current for the station auxiliaries.



Fifteen thousand kilowatt turbo-generator after erection

Protection devices of a varied character uphold a proper degree of safety in handling an exacting load. Alternator field switches, besides having the usual induction-suppression resistance, are fitted with protective gears on the main switch which operate in conjunction with a trip switch on the air-supply damper. This damper is overbalanced and is normally held open by a catch. In the event of a fire from any cause in a generator, the gear trips the main oil switch and field switch and closes the air-supply damper to the generator. All outgoing feeders are fitted with time-limit overload relays. All station motors have no-voltage and overload trips.

The erection, operation and maintenance of this sta-

tion might not be looked upon as anything unusual in America, where equipment can be transported easily and spare parts obtained on comparatively short notice in case of an unusually serious accident. In India, not only do these conditions assume alarming proportions at times, but added to it is the unreliability of labor, particularly distressing during the erection of power-plant apparatus, much of which has to be handled and set with the greatest amount of exactitude. To the power engineer this undertaking, which has been carried on so successfully, stamps itself as real pioneering. Much credit is due J. T. Mertens, the chief engineer and agent, and his associates in solving the many serious problems that have been faced in the past.

Pulverized Coal at Cahokia

BY E. H. TENNEY†

One of the most interesting and important characteristics of the use of fuel in pulverized form is in the fact that fuels of widely different quality may be successfully used. Some of the fuel now being pulverized and burned at Cahokia could not be burned satisfactorily on a stoker. In discussing the characteristics of Cahokia Station, St. Louis, therefore, as compared to other stations, this difference in the quality of fuel should be taken into account with relation to the differences in station design and in arrangement of fuel preparation and burning equipment, as well as in the efficiencies shown.

It is interesting to note the effect of the various non-combustible elements in a low-grade coal upon the economy of a station using pulverized coal.

High moisture results in an increase in power for pulverizing, in greater quantities of air for transporting, and in less-effective burning. At Cahokia the coal contains 12 per cent moisture and must be dried down to at least 5 per cent before satisfactory milling and transporting can be accomplished. This drying is accomplished by the use of waste stack gas. About 15 per cent of the gases at 410 deg. F. are drawn through the coal as it passes downward through the driers to the mills. The temperature of the gases is reduced to 140 deg. F. and the moisture in the coal to about 5 per cent.

The coal used at Cahokia contains a high percentage of ash, frequently in excess of 16 per cent. This ash is of a quality that is largely accountable for one of our most difficult furnace problems, namely, the erosion of side walls. The ash contains 18.5 per cent of iron with a fusing temperature of 2,000 deg. F. The coal also contains 5 per cent sulphur. These particular chemical elements, when brought in contact with the refractories of the side walls at high temperatures and high rates of combustion, seem to be just what is needed to melt the surface of the firebrick; in other words, the ash becomes a flux for the firebrick. In the first eight boilers at Cahokia the refractory is of a quality sometimes referred to as "balanced brick"; that is, the brick contains about equal parts of alumina and silica as the chief ingredients. It may be possible to partly overcome this side-wall erosion by changing the quality of the brick, and experiments to determine just what the proper ingredients should be, are now being made. To improve conditions, the shape of burners has been changed to throw the body of the burning fuel away from the side walls. Air has been admitted along the side wall in a way to form a protective blanket against the high furnace temperature, and the use of the burners immediately adjacent to the side walls has been discontinued. Side walls have been built vertical instead of sloping inwardly, as on the earlier installation, and now we are installing water-cooled side walls. One furnace with the Murray fin-tube water-cooled wall is now being erected, and two furnaces with tubes embedded halfway in the brickwork will be built in the spring. At the Ashley Street station we are now building a furnace for pulverized fuel, with Bailey water-cooled sides and bottom.

The use of coal of very low grade has introduced other factors in the operation of the furnaces which in plants using a higher grade of coal are of minor importance. Chief of these are the greater quantities of ash to be handled. The low fusion temperature of the ash results in slag on boiler tubes and in the ashpit and requires much care in the keeping of water surfaces clean. Where erosion of the side walls takes place, this molten brick finds its way to the ashpit and frequently requires special attention in its proper removal.

RESULTS OF BOILER TEST AT CAHOKIA POWER PLANT UNION ELECTRIC LIGHT AND POWER COMPANY

(Babcock & Wilcox Cross-drum boiler, 18,010 sq.ft. of Heating Surface)

Duration, hours	21.18
Rating, per cent	214
Coal as fired	
Moisture, per cent	6.82
Ash, per cent	11.06
B.t.u. per lb	11,713
Fired per hour, lb	13,161
Per cu.ft. of combustion space per hour, lb	1.12
Ash	
Comb. in furnace ash, per cent	0
Comb. in flue dust, per cent	2.8
Water	
Evaporated per hour, lb	107,114
Evaporated per lb. of coal, lb	8.18
B.t.u. per lb of steam	1,210.6
Temperatures, deg. F.	
Air to furnace	80
Gases leaving boilers	527
Feed water	198
Superheated steam	718
Pressures	
Superheater, lb. per sq.in. abs.	331
Drafts, in. of water	
Furnace	0.18
Uptake	0.80
Pressure feeder air	13.5
Analysis of gases, uptake	
CO_2, per cent	14.7
O_2, per cent	4.3
CO, per cent	0
Heat Account, in per cent	
Heat absorbed by boiler and superheater	84.5
Loss in dry gases	10.5
Loss in water vapor	5.0
Loss in incomplete combustion	0.3
Radiation Error, and unaccounted for	−0.3
Total	100.0

The slucing of ashes is another distinctive feature of Cahokia. The accumulation of dust from boilers and furnaces is dropped through doors in the bottom of the ashpits into a sluiceway through which water is jetted at high velocity. This ash and water flows to a receiving pit from which it is pumped to the adjacent property.

Cahokia station is not equipped with economizers, the reason being that with the cheap fuel available the saving to be effected was not sufficient to warrant the additional investment cost. Nevertheless, the test result proves that the plant is efficient. With economizers as a part of the boiler equipment probably 6 per cent would be gained in boiler efficiency.

*Chief Engineer of Power Plants, Union Electric Light & Power Co., St. Louis, Mo.

†Extract of paper read before the Cleveland Section, American Society of Mechanical Engineers, Jan. 13.

An Appropriation That Congress Should Grant

EMPLOYMENT of the X-ray to detect defects in materials has made marked progress in the last few years and in many cases provides the only method short of a test to destruction. Such apparatus, however, because of its cost and the need of expert operators and trained observers, is prohibitive for most manufacturers, especially as its use would likely be intermittent.

The government, at the Watertown Arsenal, has been obtaining some remarkable results with its present X-ray equipment both on investigations of army matériel and outside industrial work which has been sent there for test; notable among the latter are the castings for the one thousand two hundred-pound high-pressure turbine for Weymouth.

The apparatus at Watertown, however, is somewhat limited in its usefulness by its inability to penetrate some of the heavier materials in use, and there is now a request before Congress for an appropriation to cover the cost of a 600-volt X-ray machine for installation at this arsenal. It is receiving the hearty indorsement of several recognized societies, investigators and manufacturers.

It would be an excellent investment both from the viewpoint of the government and as an aid to private industry. It would enable industrial concerns, where desirable, to have specific apparatus tested at a nominal cost which in the aggregate would largely defray the expenses incident to the maintenance and operation of the machine and would greatly aid the government in further investigations toward improvement of ordnance matériel. Moreover, its application to industrial problems might be regarded as a further step in the co-operation between the government and industry looking to industrial preparedness.

Inexpensive Remodeling Of Power Plant

THE owner of an inefficient power plant who has called upon his chief engineer or a consulting engineer for a report, is prone to think that all the changes recommended must be carried out as one. This has prompted the abandonment of many plants by reason of the financial inability of the owner to carry out the plan for complete renovation.

In almost all plants it is possible to segregate the machinery into several distinct groups. Improvement can be carried on in one of these units without disturbing in any way the functioning of the remainder of the plant. In situations when a large expenditure is impossible, there is no reason why the boiler room, for example, should not be modernized. The increase in steam-making efficiency brought about through the installation of new boilers, or even rebuilding of the furnaces, will be reflected in the total plant-operating costs. Stokers can often be installed with little changes to the boiler room other than raising of the boilers or lowering the ashpit floor line. If high pressures are permissible with the existing equipment, superheaters can be added with but a slight change in the settings. In the same way feed-water heaters, better feed pumps, new piping and the like can be added from time to time as finances permit. The same argument applies to the engine room, where frequently a unaflow engine can be installed on the foundation of an existing single-valve machine. By using the old generator and other equipment, the installation costs are moderate.

While a complete modernization may be desirable, the piecemeal plan works out quite satisfactorily, and each change is reflected in a saving in operation costs, which saving paves the way for the installation of more machinery.

Economy in Small Power Plants

THE heat consumption per kilowatt-hour has been greatly reduced in large power stations of recent years. These are so organized that in almost every case one man is made responsible for the efficiency of all individual units and of the station as a whole. This man is an expert on boiler and furnace operation, on station instruments and on practical operating methods. Such an employee is of great value to the station and is usually well paid for his services, for he can effect real dollar savings in the operation of the plant. The field of power-plant economy has proved a lucrative one for many college graduates and often leads to more responsible positions higher up in the organization.

Public-utility companies with scattered holdings, often including many small plants, have followed the same scheme of organization and have their men who are experts in securing high plant economy and who can train the operators in the best method of handling the plants. These specialists travel from plant to plant watching and checking performance. A similar practice is followed by large industrial concerns which have scattered plants in various locations.

All these organizations fully realize the value of expert advice and control, the intelligent use of instruments and the need of trained operators. They have found that large financial savings may be effected by employing specialists to look after these factors.

The conditions in the average small power plant are quite different. The direction of the plant is left to a chief engineer, usually a hard-working conscientious practical man who does the best that he knows how. He has risen from the ranks, but seldom has had an opportunity to work under expert direction where modern methods and instruments are employed. He may know of these instruments, but is unable to present his case to the owner in a way that would lead to the purchase

of these aids in efficient operation. As a result the plant economy is poor and though the men would often like to do better, they have no means of checking up performance and thereby setting up standards.

A great opportunity for co-operation to secure better economy exists among owners of small power plants. Steam users' associations are organized in Great Britain and on the Continent for this purpose. These associations engage experts in boiler and plant operation and turn the direction of their plants over to these men. As a result these small plants are run with a high degree of efficiency and appreciable savings are made for the members of the association.

It should not be difficult to organize similar associations in many of our large and even small manufacturing centers. A fuel-economy expert could be secured and a central fuel-testing laboratory established. Modern instruments to indicate efficiency could be installed under the direction of this expert, and he might even go so far as to remodel plants to get better results from them. Such methods of operation would not only save fuel, but would also undoubtedly decrease the quantities of smoke discharged from the chimneys of small plants and thereby decrease the smoke nuisance. This expert would be able to find uses for waste steam and waste heat in many plants. Chambers of commerce or boards of trade should be the means by which these associations could be organized.

Where such organization cannot be brought about, there is an opportunity for individual effort. Almost any enterprising engineer with a little capital, backed by technical knowledge and experience, could establish the necessary fuel and oil testing laboratory and then sell himself to the small-plant users to control the operation of their plants. Both would gain by this scheme, the owner by a reduction in the cost of operating his plant, the engineer by increased income.

Turbine Efficiencies Misleading

PRIME MOVER efficiencies are frequently taken as a basis of comparison, with the result that misleading or erroneous conclusions are drawn therefrom. When the initial steam condition and exhaust pressures are identical, the Rankine cycle efficiency ratios, or the steam consumption rates, do express correctly the relative economical merits of the turbines or engines. However, when under different steam or exhaust conditions, these quantities may mislead in this regard and therefore fail as measures of refinement in design or construction.

For example, an ordinary condensing unit operating on saturated steam, would be appreciably less efficient than the same machine under identical conditions except that the incoming steam is given a twenty-degree superheat. While in the latter case the efficiency is higher and possibly two per cent less steam is required, it is obviously not due to improvements in the turbine. It follows, also, that a turbine designed for a low superheat would cost more to build with an efficiency equal to one for highly superheated steam, other conditions being the same. Differences in steam and exhaust pressure should also be considered from this viewpoint.

Generally speaking, it costs more to construct stages for very high pressure with efficiencies equal to those of medium pressure. Since steam volumes become smaller at higher pressures, friction loss tends to increase owing to the denser steam. As a result stages are frequently designed with decreasing efficiency as pressures higher than a certain medium are encountered.

In the same manner stage efficiency tends to become lessened at pressures below a certain medium range. Here volumes increase rapidly, requiring relatively more blade and surrounding material or else higher steam velocity. Greater steam speed may mean more relative friction loss, which may be aggravated by the tendency to form water at lower exhaust pressures. The leaving loss, representing the velocity or unused energy in the escaping steam, varies about as the square of the blade speed.

Thus it appears that as pressures are raised above a certain medium value and exhaust pressures similarly lowered, Rankine efficiency ratios tend to be impaired. Higher tensile strength or other factors may be required, and a more exacting task is set for the designer of the steam path through the turbine, resulting in a more expensive construction if these tendencies to lower efficiency are to be counteracted.

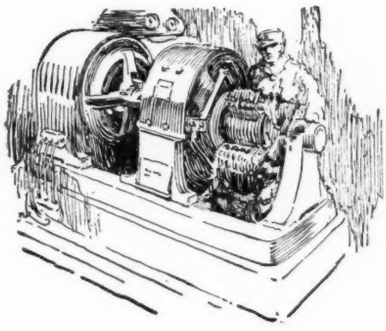
The relative degree of internal refinement may be indicated by changing the prime-mover efficiencies or water rates to correspond with a single set of initial steam conditions and exhaust pressure. There are no general data that may be applied for correcting steam consumptions or efficiencies of different types of turbines to steam and exhaust standards for comparison, with equal accuracy. They may be determined from tests or by manufacturers' guarantees. Generally speaking, the greater the range through which a correction is applied to a given machine, the greater the disadvantage under which the unit is theoretically placed by departing from designed conditions, but without changing the actual construction. In fact, circumstances may be encountered whereby different design would be justified and therefore comparisons would be of less value. In such cases, however, an approximate correction may be arrived at, with allowance for reasonable changes of construction which would represent more nearly a true comparison than if neglected.

Balancing Efficiency and Maintenance

IN CONNECTION with boiler operation some engineers make high thermal efficiency their hobby; others can see nothing but low maintenance cost. Yet, the really important thing is low total cost, and the degree of its attainment measures the ability of the engineer in charge. The engineer who is provided with the necessary boiler instruments and has had several years' experience with a given setting and fuel, ought to have enough data at hand to make a fairly close estimate of the percentage of CO_2 or excess air he can carry with maximum commercial economy.

Let him set down on a sheet of paper various possible percentages of CO_2 with the corresponding efficiencies and yearly maintenance costs estimated from his own experience. The cost should, of course, include an allowance for any inconvenience or loss of boiler service that may be occasioned by the necessary repairs. Assuming the same load in all cases, he can then write down opposite each percentage of CO_2 the estimated yearly cost for fuel, including fuel and ash handling. The aim should be to operate continuously at that percentage of CO_2 which shows the lowest total yearly cost for fuel and for maintenance.

Practical Ideas from Practical Men



WITH a view to stimulating engineers into the habit of recording for the benefit of brother engineers, unusual occurrences, how these were met and other practical expedients adopted in the operation of their plants, Power has decided to award two cash prizes each month during 1925. One of $25 for the best and another of $15 for the second best practical letter on plant operation or practical kinks received during the month. This is in addition to payment for the contribution at space rates. Three prominent operating engineers have been invited to act as judges. The winners will be announced the succeeding month.

Testing Welded Pipe Joints

While perhaps there is much to be said in favor of the welding method of making pipe joints, it must not be forgotten that this is a process where the human element should probably be taken into greater consideration than in any other similar work, in order that a weld may be considered as a perfect and homogeneous junction of two pieces of metal. In view of this I am of the opinion that more frequent individual tests should be made than is usually the case in the average shop—tests of a simple nature that a foreman in charge of welding can make as a matter of routine.

In a shop where there was a considerable amount of both electric and acetylene work done, and also a large labor turnover among the welders, I made it a practice periodically to test work going on, no matter how good a welder the man was. The following is a short description of the tests used.

A piece of welded butt joint is selected and first a chisel used on it to see if a good bond has been made between the welding rod and metal. Then it is sawed through the center of the weld parallel to the joint, filed and buffed up to a good finish and cleaned off with alcohol. A solution of potassium iodide is then applied (containing free iodine). When dry it is cleaned off, any porous spots will show where the iodide has attacked them. Then a section is sawed at right angles to the weld and treated as before, again indicating the porosity if present. The line of fusion will also appear clearer, showing as a sharply defined line if there is poor fusion, due probably to underheating or else a gradual merge of the two metals, if a first-class weld.

Another method is to give the sample a cold-bend test in a vise. This is somewhat drastic, but a piece of three-eighths plate that is well welded, will stand being bent double before showing signs of cracking. In comparing this with electric welds, it has been my experience that the latter will stand only about a right-angle bend before showing signs of cracking. It would be of interest to hear other experiences along these lines.

In tensile tests, taken of work by both methods, I found that acetylene welds showed a slightly greater strength, with a more fibrous section at the break than the electric, which was decidedly close-grained and brittle.

On a welded 36-in. pipe-line job of which I had charge, there appeared considerable trouble with porosity occurring in electrically welded shop joints. The rods used were covered with chalk, but still oxidization was present. Finally, the customer suggested that rods covered with a blue asbestos slag be used. These were procured at considerable expense, but a more perfect weld resulted.

However, the cost of these rods made them prohibitive and by testing the work out it was found that the trouble was in the man, who was a first-class acetylene welder, but with not enough experience in controlling his arc. I mention the fact of such rods, as I have not since heard of their use and would like to know of tests made with them by others.

Los Angeles, Calif. MAURICE C. COCKSHOTT.

What Is the Best Method of Repairing a Girth Seam?

In the early part of last year we installed a new 72-in. by 18-ft. horizontal return-tubular boiler, with the furnace arranged for hand firing. The boiler was built from $\frac{17}{32}$-in. sheets for 150 lb. working pressure, and it was ordered built strictly to the A.S.M.E. Boiler Code. Later a representative of the builder admitted that they had not complied with paragraph 254, page 71, which reads as follows:

> After drilling or reaming rivet holes, the plates and butt straps shall be separated, the burrs and chips removed, the plates and butt straps reassembled metal-to-metal with barrel pins fitting the holes and with tack bolts.

After firing the boiler one week, it was found to be leaking in the front girth seam. This was calked dry and the boiler was again placed in service. After being on the line a week, it was found to be leaking seriously again. This time twelve rivets were removed, holes countersunk and new rivets driven. In the course of the next two weeks the boiler showed leaks on two occasions and was calked. It was placed in service again and ran along some time. It then began to leak badly, and the rivets were again replaced and that part of the sheet laid up hot. After the usual test the boiler was again placed in service. After being operated one week, it was again found to be leaking. This time a baffle wall with a 36-in. arch was installed in the combustion chamber, and still the same result. The boilers are operated on the peak load at about 150 per cent of rating and the draft is carefully regulated. The rivets have all been driven by air gun using 100 lb. pressure.

From previous experience I think I can stop the trouble by again removing the same rivets and driving them by hand, countersunk, then making an acetylene weld along the inside lap, also a light weld around the inside heads of the rivets. With this arrangement there would be no more metal than with the ordinary button-head rivet. Also the weld would not be subject to tensile strain, as it would be on the inside and not subject to the direct heat from the furnace. However, before making this repair I would appreciate suggestions from readers of *Power* as to the most practical method. C. R. RAGSDALE.

Lebanon, Ind.

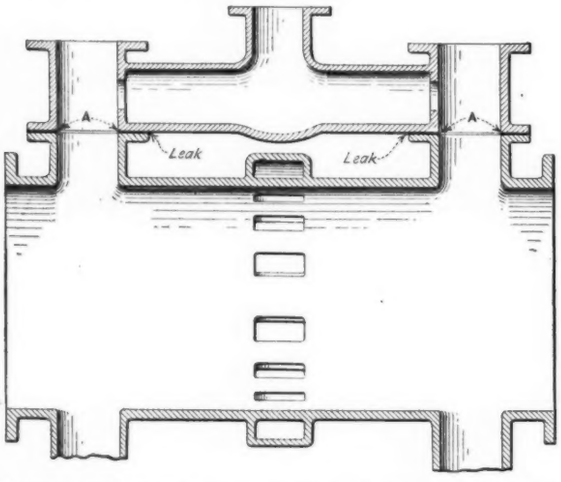
How the Leak Was Stopped at a Minimum of Labor and Expense

A method we employed recently in stopping a leak in a flanged connection proved so satisfactory that it is passed along for what it is worth and may help someone else as much as it did us.

A 16x19-in. unaflow engine, operating non-condensing on saturated steam at 150 lb. pressure developed a bad blow between the valve-chamber casting and the cylinder casting, as indicated at *A* in the illustration.

To renew the gasket meant taking down the throttle valve and steam separator and supporting a rather long expansion bend in a place where there were no conveniences for such work, as well as the usual labor of removing and replacing the gasket. The valve-chamber covers were removed, also the valves and cages, and after inspection, it was decided to try an experiment although we were not very optimistic as to results.

Accordingly, "Smooth-On" No. 3 was painted around the joint as indicated at *A* and well worked in. The excess was carefully wiped off and the cages, valves



Valves and cages were removed and "smooth-on" painted around joint

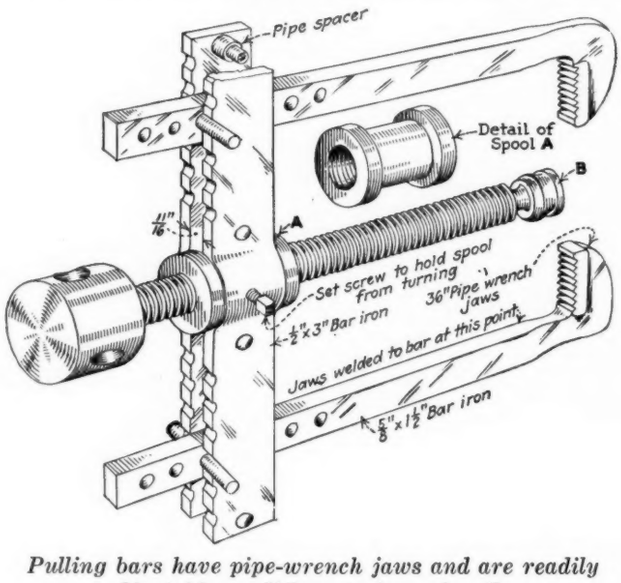
and covers replaced. Steam was slowly turned on and the blow dwindled to a small drip.

The unit was kept running for about ten minutes without load to heat the parts thoroughly and was then shut down and "Smooth-On" No. 1, mixed to a soft putty, was calked from the outside into the places where the joint was dripping, and allowed to set till the next morning. The time required to make the repair was less than two hours and the cost of material about twenty cents. After three months' operation the joint is still tight. It would seem as if the same treatment might be effective in leaks between the main frame and the cylinder. S. W. STEARNS.

Beloit, Wis.

Pipe-Wrench Jaws Used in Making Pulley-Puller

There are numerous ways of making pullers for drawing pulleys off a shaft, but the one shown herewith has proved satisfactory and may be of interest to other readers. Two pieces of ½x3-in. flat iron were



Pulling bars have pipe-wrench jaws and are readily adjustable to different sizes of pulley

heated and bent to fit over a spool as shown, leaving a space of about 1⅛ in. between them. These two pieces were fastened over the spool by four rivets with pieces of pipe over the rivets for spacers.

The spool was turned up first and threaded in the lathe and a long jackscrew turned to fit the thread in the spool, leaving a large head at one end through which two holes were drilled at right angles as shown. The other end was fitted with a ball-and-socket bearing piece. This was considered the most practical for the different kinds of jobs that would be encountered. After some discussion as to the suitable gripping ends, we decided to use two old 36-in. pipe-wrench jaws that were lying around. A piece of ⅝x1½-in. flat iron was welded to each, and a series of holes were drilled in the straight ends. The cross-bars were notched as shown, which makes the puller readily adjustable to almost any size. Before the two bars were riveted together, the spool was countersunk and a setscrew run through one of the bars to prevent the spool from turning.

This outfit worked so well that later on we made a smaller puller by using smaller wrench jaws and shorter lengths of flat iron. ANTHONY FETTE.

Cincinnati, Ohio.

One of the essential factors in the successful operation of fuel oil burners is the necessity of keeping them clean. Even the best of oil is likely to carbonize at the burner tip and in the passages of the burner. Any such deposit is sure to cause trouble.

Comments from Readers

Low-Pressure Boilers

There has appeared in recent issues of *Power* correspondence advocating the installation of high-pressure boilers for heating. This matter is a very important one, in view of the high cost of fuel, but unfortunately, a dogmatic statement that a certain system is best, unless it is backed by reliable data, does not form a proper basis for an engineering decision.

In many cases the question of labor cost is doubtless the governing factor, and many heating plants of moderate size are being run by janitors in the time which they can spare from other duties, but of course this can be done only with low pressure. This method of operation is no doubt far from ideal from the point of view of fuel conservation, but upon a dollars and cents basis it is often hard to beat.

I think it would be of great interest if you would publish some reliable data, based upon actual operating conditions, as to the relative cost of investment and operation of high-pressure and low-pressure systems.

Some of the largest boiler manufacturers in the country are claiming as much as ten pounds evaporation for their low-pressure boilers, and although no one expects to average anything like this in practice, in view of the high standing of the firms making these claims it must be assumed that they can substantiate them under test conditions.

Assuming that their claims are correct, how much better can we do with high-pressure boilers, assuming of course, that no power is generated and the fireman in each case is equally competent?

I am not making the claim that low-pressure boilers are more efficient than high-pressure ones, but until I have more reliable data I am not willing to agree with your correspondents that the people who install them are necessarily lacking in sound engineering judgment.

JAMES O. G. GIBBONS,
Newark, N. J. Consulting Engineer.

Heat Cycle Efficiencies

In an article contributed by Lionel S. Marks in the January 20, 1925, issue it is suggested that the ideal cycle efficiency be defined as that obtained when every portion of the heat taken in, operates through a Carnot cycle, the temperature limits of which are: 1. The temperature at which heat is taken in, and (2) the exhaust temperature at which the heat is rejected from the cycle.

In explaining how the ideal regenerative cycle efficiency can be obtained, the case of regeneration is taken up to the temperature at which the steam would become dry and saturated when expanding adiabatically. This cycle is as shown in the temperature-entropy diagram, Fig. 6 of his article. The statement that with complete regeneration, the curve *ef* is parallel to *ga*, is in this case correct, but if the feed water were heated to a temperature above that at which the steam becomes dry and saturated when expanding adiabatically, it would not apply.

Where the combined regenerative and reheating cycle is used and in some cases with the regenerative cycle alone, the feed water may be heated to a temperature above that at which the adiabatic crosses the saturation line. Some of the heating must in this case be done with superheated steam, since in a perfect engine all the heat corresponding to the superheat of the steam could not be absorbed by the water at the same temperature at which it was taken from the cycle. Therefore, the section of the cycle diagram corresponding to *ef* would not be parallel to *ga*. In this case a small portion of the heat would be taken from the cycle at the highest temperature to which the steam is superheated, but heat would not be added to the feed water at a temperature any higher than that corresponding to the working steam pressure.

With regeneration to the temperature at which the steam becomes saturated in adiabatic expansion, the ideal cycle efficiency can be calculated by the use of simple equations. However, with heating to a higher temperature, these equations will not apply, since they do not take account of the degradation of heat due to the heating of some of the water with superheated steam. It would be of interest to know how Mr. Marks would interpret his definition for the ideal cycle efficiency in this case of heating to temperatures above that of saturation in adiabatic expansion. For practical use the ideal efficiency should be such that it can easily be calculated. However interpreted, the exact ideal efficiency with high-temperature heating will be difficult to calculate.

J. DARE MCADOO.
New Kensington, Pa.

Boiler Designers Should Study the History of the Art

A study of the history of the superpressures of a century ago would, I believe, be of the greatest value to steam-users who would like to use pressures of 400 to 500 lb., if they knew how and were not prevented by the usual self-love of moderners from advancing because they know that advance means retrogression to ancient practice. It is a good sign when a prominent boiler company admits that the present drum-type boiler is standing in the way of an advance backward to Perkins' 2,000 lb. pressure practice. At the risk of repeating what is already known by engineers, the opinion mentioned is one of many included in the report by the Prime Movers Committee of the National Electric Light Association. It was stated: "We feel sure that for pressures of 600 lb. upward a boiler entirely different from the present generally accepted types must be developed."

Only last December I drew from the memory of an intelligent fireman an extraordinary picture of the Perkins' boiler he had fired for a number of years on

the premises of Heal's, a furniture factory of over 100 years' standing, in the Tottenham Court Road, London. This boiler had loops of tubes in the fire which formed the grate itself, and supplied practically "red-hot" water to heat a boiler, screened by a heavy bedplate from the direct action of the fire. These tubes worked at 1,500 to 2,000 lb. pressure with water that circulated unceasingly from fire through boiler and back to grate. This boiler was continuously at work for 65 years and was still good, as also the engine, when it was smashed up by hammers to facilitate its removal as scrap, in 1915. A second similar boiler, of 35 years' service, stood by the side of the older one and served likewise as scrap.

When the works at King's Cross was removed to Peterborough, 300 hands were employed. Now the firm, Baker & Perkins, employs 4,000. It is still making the "stopped-end" hermetically closed heating tube, each of which is tested to 3,000 lb. derived from the J. Perkins system of 1832. This was patented in 1836 in the form of a locomotive boiler, with the engine of the unaflow design similar to the present Stumpf marine-type. Perkins used this for locomotives, and at Peterborough I found a large, finely executed drawing of this identical engine on paper yellow with age, as well as the complete drawings of a steam-gun boiler, which in modified form is the A. M. Perkins' heating system as applied to hundreds of large buildings, museums, palaces and private houses in London, England, Switzerland, Holland, etc. Jacob Perkins provided a cap to fill his hermetic tube with water, but today the tube ends are welded up. Profiting by experience of the damage Perkins suffered by publicity, his successors avoid it, especially with regard to these "stopped-end" tubes, first patented in 1836.

Some twenty large folios, dating from 1831, relating to the business of A. M. Perkins, were examined by me last week while sitting in the spacious board room of the firm, under the large life-sized oil portrait of Jacob Perkins dressed in knee breeches of the Washington period, cherubic and quizzical, with eyelids which seem to flutter as he looks eternally down on the big locomotives of the N. E. Ry. switching all day long in the yards below.

Two members of the present staff served under Loftus Perkins, and one knew Angier March Perkins. From these engineers I derived much information that I have not seen in old literature, a little of which would help the gropings of present-day engineers to make high pressures commercially successful. For example, even with present moderate pressures it is stated that one of the annoyances is the frequent bursting of the glasses of water-gages. Now, Loftus worked up to 1,000 lb. and his regular pressure was 700 lb., which present makers do not know how to render practical. He had no trouble with bursting glasses because, with an extremely simple arrangement, which any apprentice could make, in mica Loftus overcame the difficulty now met 50 years later. The question occurs: Why grope blindly instead of learning frankly from past experience?

Yesterday, without even giving my name to anyone, I came suddenly on a fireman in the middle of his work who immediately made reflections on the boiler at Heal's, stating that he never could understand why it was so *unusually efficient* in rapid steam production, although he had been a fireman on locomotives and later a fireman of modern water-tube boilers in a central power station. He could not understand, so he said, how a tubular water grate apparently always red-hot, as was also its loops above the fire, could remain in perfectly good condition for 65 years in spite of the rough use from the pick and other tools used in grate-bar cleaning.

Those tubes bore a pressure of anything from 700 to 1,500 lb. in their latter years, and this suggests that the boiler company referred to, is right in its view of developing other boiler types for superpressures.

London, England. CHARLES R. KING.

How Much Does the Water Level Drop in Different Types of Boilers?

The following data are presented as a supplement to my article on page 990 of the Dec. 16, 1924, issue, discussing the subject of water-level drop in different types of boilers. The accompanying curves show the results obtained by actual test.

The object of these tests was to determine the change in water level due to abnormal changes in rating, and to ascertain if the fluctuation in water level was sufficient to carry water over into the steam lines if proper precautions were not taken.

The boilers on which the test were conducted were changed from normal operation to a banked condition

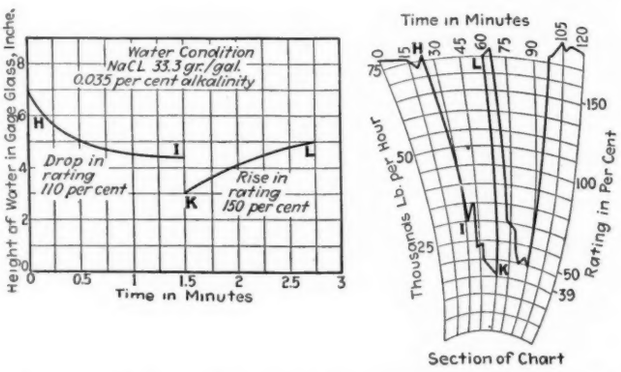


Fig. 1—Curves showing relation of water level and change of rating to time, on a 13,700-sq.ft. cross-drum boiler

for 20 to 30 min., then brought up to normal rating again as quickly as possible by supplying the correct amount of air. The results were as follows:

	13,700-Sq.Ft. Boiler		18,600-Sq.Ft. Boiler	
Initial rating, per cent	220	220	180	180
Drop in rating, per cent	110	82	145	167
Drop in water level, in.	2.6	1.4	11.7	15.2
Time in min.	1.5	0.5	1.25	2.25
Increase in rating	150	...	145	83
Increase in water level, in.	2	...	10.8	6
Time in min.	1.25	...	2.75	3
Lowest rating, per cent	39	...	70	...
Condition of Water:				
Grains of salt per gal.	33.3	...	41	
Alkalinity, per cent	0.035	...	0.08	

Further tests on the smaller boiler duplicated the first tests.

The first test on the large boiler was made with 5.4 in. of water in the gage glass. This dropped out of sight in 30 sec. and the rating had dropped approximately 82 per cent (curve *AB*). The second test was made with 11.7 in. in the glass and as soon as the water had reached the bottom of the glass the air

supply was opened up and the rating increased to its initial point (curve *CDE*). The third test was made with the maximum allowable amount of water in the gage glass. The level dropped to the bottom of the glass in this test (curve *FG*).

When boilers having relatively small steam liberating space or having the characteristic just described, are

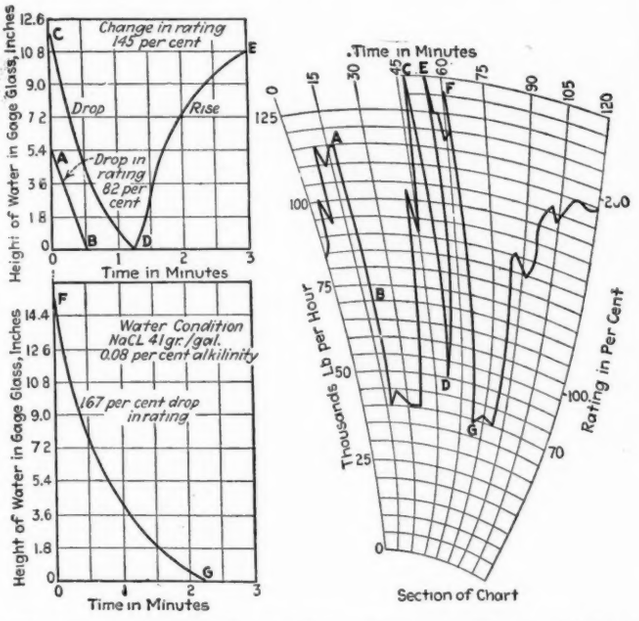

Height of Water in Gage Glass, Inches
Change in rating 145 per cent
Drop
Rise
Drop in rating 82 per cent
Time in Minutes
Water Condition NaCL 41 gr./gal. 0.08 per cent alkilinity
167 per cent drop in rating
Time in Minutes
Time in Minutes
Thousands Lb per Hour
Rating in Per Cent
Section of Chart

Fig. 2—Curves similar to those shown in Fig. 1 obtained from tests on an 18,600-sq.ft. cross-drum boiler

temporarily banked to take care of abnormal conditions, the feed should be shut off as soon as water appears in the glass.

H. H. BAUMGARTNER, Tech. Asst.,
Public Service Elec. & Gas Co. of N. J.
Newark, N. J.

The Economies of Interconnection of Large Steam Power Systems

In the Jan. 13 issue Mr. Douglas discusses the economics of interconnection of large steam power systems. There is no question that his arguments are sound, that many interconnection systems look fine on paper and have a popular appeal, but earn little return on the investment.

But is it not true that their contribution to reliability of service may itself justify them? The system that is interconnected with another does not have to carry as much reserve capacity for emergencies. Certainly, this is worth something. It is also more sure of giving its customers continuous service. This, too, is worth something, although a definite value can hardly be assigned to it.

Consider the part that interconnection has played in building up the new great industrial centers of the South, especially Birmingham, Ala., and some others which are supplied by the Alabama Power Co.'s network of lines. An ever-increasing supply of power at low rates has been one of the biggest factors in attracting industries from the North to build factories and mills in this company's territory. This result could certainly not have been accomplished without interconnection. It we are talking about the *economics* of the situation, anything that will help distribute large industries more evenly over the country has some economic advantages.

The statistics Mr. Douglas has quoted show in several interconnection centers a decrease in average load factor over a period of years, rather than the anticipated increase. But is it not possible that without interconnection the decrease might have been even greater? He has pointed out that "much of the industrial power which these large systems now supply is highly competitive with power produced in small isolated plants." Some of these loads have tended to cut down the average load factor, and interconnection has probably helped rather than hindered.

Mr. Douglas also says, in discussing the highly competitive business, that "some of the industrial loads have been taken on at rates that yield a very meager profit, because higher rates would not get the business." And yet these very loads later become profitable, because they make necessary additional generating equipment, in which is incorporated the newest technical developments which cut the cost of power making.

In an address to his organization, William H. Patchell, president of the Institution of Mechanical Engineers of Great Britain, discussed the enormous size of the boilers which are practicable in American central stations. He said, "It is not because American engineering is better than our own; it is the direct outcome of the skill and zeal of those who handle the sales department of the electricity-supply undertakings."

If we consider that the continued activity of the sales forces has kept on piling up business and has resulted in a demand for new and more economical equipment—equipment that brings into play extensions of available heat range and other processes that have long been known but have not been widely used, and if we consider that this equipment has reduced the average cost of making current and made possible rate reductions which bring still more business, then we must admit that those "meager profit loads" have performed some service after all. They have helped to make possible this tremendous increase in per capita consumption of electricity, which in turn has given us cheaper manufactured products and has contributed toward making American labor the highest paid in the world.

Mr. Douglas also says that "as coal continues to advance in price, and it surely will, power rates will necessarily have to increase." This statement, logical as it may seem at first glance, should not be taken too literally. Electricity is one of the very few commodities which can be bought now for less than it could in 1913 and 1914. And yet coal prices are much higher now than then.

Moreover, the price of coal is not the predominating factor in the cost of power generation. If it were, why would so many of the large utilities go to the fields where the finest bituminous coal is sold for a comparatively high price, when they could be certain of a large supply of low-price steam sizes of anthracite? To be sure, most wholesale power contracts carry a coal-cost adjustment clause, but it is still to the interest of the utility to have this cost as low as possible. And if coal prices tend to become exorbitant, lower grades of fuel and better methods of handling and storing will quickly come into play to make the net result about the same. Certainly, the experience of the last ten years has not borne out Mr. Douglas' statement, and present trends indicate little change.

W. J. RISLEY, JR.
North Glenside, Pa.

Questions and Answers

Conducted by

Franklin Van Winkle

Ammonia Charge for New Plant

What is the rule to determine the correct amount of ammonia to be put in a new plant per ton of refrigeration compression system for ice making? *C. M. K.*

A common method, when an ice plant uses the flooded system of coils is to figure on 50 lb. of ammonia per ton of refrigeration plus 24 lb. for each set of condenser stands. In case of direct-expansion cold-storage rooms, allow ¼ lb. of ammonia per linear foot of coil plus 24 lb. per condenser stand.

Pitch of H. R. T. Boiler and Level of Water-Gage Glass

What should be the position of the gage glass in a return-tubular boiler relative to the level of the tubes, and the number of inches of pitch of the flues in a 72x18-in. return-tubular boiler? *C. K.*

The fire tubes of a return-tubular boiler are intended to be parallel with the center line of the shell, and for drainage of the boiler toward the blowoff outlet an 18-ft. boiler would be set about 2 in. lower at the rear end. The lowest visible part of the water-gage glass should not be lower than the lowest safe water line for the boiler, which is commonly considered to be 2 in. above the highest part of the fire tubes, and with the boiler pitched downward toward the rear end, the lowest visible part of the water-gage glass should be 2 in. above the highest level of the tubes at the front end of the boiler.

Double-Eccentric Corliss Engine

Why are some Corliss engines provided with two eccentrics and two wristplates? *C. E. M.*

In the ordinary single-eccentric Corliss engine, where all four valves are operated by a single eccentric and wristplate, cutoff must occur inside of one-half stroke, and since for obtaining release and compression it is necessary to place the eccentric more than 90 degrees ahead of the crank, the range of cutoff becomes less than one-half stroke.

By controlling the steam valves with a separate eccentric and wristplate, the eccentric may be set less than 90 degrees ahead of the crank, and by adjusting the connections so the steam valves will be opened at the beginning of the stroke, the opening occurs before the wristplate arrives in the central position. Since cutoff may occur between the time the valve is picked up and when the wristplate has swung farthest to one side, by this use of an eccentric and wristplate independent of the wristplate for controlling the exhaust valves, the range of cutoff may be increased to more than one-half stroke without affecting the setting of the exhaust valves.

Terry Filter Cloth

What is terry cloth, which is used as a filter for removing grease and dirt from boiler-feed water? *W. P. L.*

Terry is the name given to fabrics with a looped pile, like the ordinary bath toweling. When used as a filter cloth for straining solids and impurities out of feed water, the cloth, made of linen to obtain greater strength and durability, is backed by a brass or noncorrosive screen over which the cloth is spread and held. The filter cloths are removed from time to time as required for cleansing or replacement.

Same Evaporation Capacity with Different Water Levels

If there are 2½ gages of water in a boiler and the water level is reduced to 1½ gages, would the evaporative capacity be increased? *T. J. H.*

Evaporative capacity of a boiler is its capacity to transfer heat to the water in the boiler. If the water is already heated to the temperature of evaporation corresponding to the operating pressure, the evaporative capacity and amount of steam generated in a given time would not be changed from lowering the water level, because the same transfer of heat would be supplied for latent heat of evaporation of the same quantity of water. In starting up a boiler with a lower water level, the temperature of evaporation is reached sooner because there is less water to be heated, but when that temperature is once established, generation of steam proceeds as rapidly with 2½ gages as with 1½ gages of water in the boiler.

An Eight-Pole Rotor in a Six-Pole Stator

A new 7½-hp. 6-pole slip-ring motor had to have the rotor replaced, and by mistake an 8-pole rotor of same diameter was received and installed. The motor would not start even with the slip rings short-circuited. With the slip rings short-circuited, why would the motor not start and run as a squirrel-cage motor? If the motor could have been brought up to synchronous speed through other power than its own, would it have continued to run? All these circumstances would be under no-load conditions. *W. M.*

When the slip rings are connected together on the rotor of a wound-rotor motor, it is not converted into a squirrel-cage machine as your question would imply. The current has to go in definite paths in the winding just the same as when the starting resistance is connected in series with the windings. Therefore, whether the slip rings are connected to an external resistance

or are short-circuited, the rotor has the same number of poles as it was wound for. With an 8-pole rotor in a 6-pole stator there will be cases where counter torques will be produced and the motor will lock.

If the motor was brought up to synchronous speed through other power than its own, it would not have operated satisfactorily, although it is possible that it might have kept turning but would develop very little torque. It might be added that with a normal wound-rotor motor if the slip rings are short-circuited and the motor connected to the line with the rotor at rest, it is very likely to lock and refuse to start. Therefore it is not surprising that an 8-pole rotor refused to start in a 6-pole stator.

Utilization of High Back Pressure

Where exhaust steam is needed for process work, is it advisable to operate a reciprocating pump under any condition with 25 lb. gage back pressure, and is there any advantage or disadvantage of compounding in case the steam is needed for process work? *B. G. J.*

If all the heat in the exhaust can be utilized, it is immaterial how high the back pressure may be so long as the pump or engine is able to perform its work. For performance of a given amount of work there will be absorption of the same amount of heat, regardless of the type of engine. However, the greater the ratio of expansion of steam in the engine cylinder the wetter the steam at release, and consequently by compounding there is a larger percentage of water contained in the exhaust. Since in process work the heat contained in water is not so readily utilized, there is usually less economy in utilizing the exhaust of a compound than of a simple pump or engine, and in either case, where the exhaust can be utilized only as steam, the higher the back pressure the higher the economy.

Efficiency of Butt and Double-Strap Joint Quadruple-Riveted

What is the efficiency of a quadruple-riveted butt and double-strap joint in which the main plates are $\frac{5}{8}$ in. thick and butt straps $\frac{1}{2}$ in., each of 55,000 lb. T.S.; pitch of rivets of outer row, 16 in.; diameter of rivet holes, 1 in.; shearing strength rivets, 44,000 lb. per sq.in. single shear and 88,000 lb. in double shear; and crushing strength of material, 95,000 lb. per sq.in.? *M. L. C.*

The cross-sectional area of rivets after driving would be 0.7854 sq.in., and for a unit of pitch P in the sketch, there would be three rivets in single shear and eight rivets in double shear. As the main plates are $\frac{5}{8}$, or 0.625 in. thick, then for a length of joint P:

(1) Strength of solid plate $= 16 \times 0.625 \times 55{,}000 = 550{,}000$ lb.

The strength of the joint per unit of length P would depend on the least value obtained from the following considerations:

(2) Strength of plate between rivet holes in the outer row $= (16 - 1)\ 0.625 \times 55{,}000 = 515{,}625$ lb.

(3) Shearing strength of eight rivets in double shear plus the shearing strength of three rivets in single shear $= 8 \times 88{,}000 \times 0.7854 + 3 \times 44{,}000 \times 0.7854 = 656{,}954$.

(4) Strength of plate between rivet holes in the second row, plus the shearing strength of one rivet in single shear in the outer row $= [16 - (2 \times 1)]\ 0.625 \times 55{,}000 + 1 \times 44{,}000 \times 0.7854 = 515{,}807$.

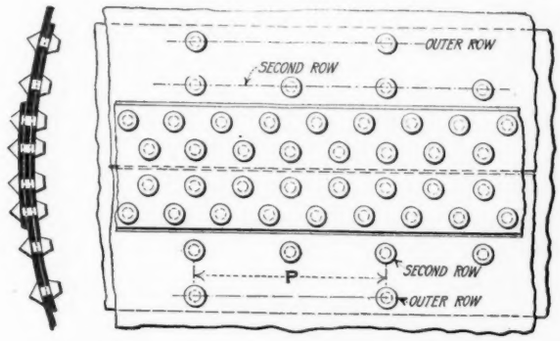
(5) Strength of plate between rivet holes in the third row, plus the shearing strength of two rivets in the second row in single shear and one rivet in single shear in the outer row $= [16 - (4 \times 1)]\ 0.625 \times 55{,}000 + 3 \times 44{,}000 \times 0.7854 = 516{,}172$ lb.

(6) Strength of plate between rivet holes in the second row, plus the crushing strength of butt strap in front of one rivet in the outer row $= [16 - (2 \times 1)]\ 0.625 \times 55{,}000 + 1 \times 0.5 \times 95{,}000 = 528{,}750$ lb.

(7) Strength of plate between rivet holes in the third row, plus the crushing strength of butt strap in front of two rivets in the second row and one rivet in the outer row $= [16 - (4 \times 1)]\ 0.625 \times 55{,}000 + 3 \times 1 \times 0.5 \times 95{,}000 = 555{,}000$ lb.

(8) Crushing strength of plate in front of eight rivets, plus the crushing strength of butt strap in front of three rivets $= 8 \times 1 \times 0.625 \times 95{,}000 + 3 \times 1 \times 0.5 \times 95{,}000 = 617{,}500$ lb.

(9) Crushing strength of plate in front of eight rivets, plus the shearing strength of two rivets in the second row and one rivet in the outer row in single shear $= 8 \times 1 \times 0.625 \times 95{,}000 + 3 \times 44{,}000 \times 0.7854 = 578{,}672.8$ lb.



Butt and double strap joint quadruple-riveted

As the least strength is derived from consideration (2), the efficiency is (2) ÷ (1), or $515{,}625 \times 100 \div 550{,}000 = 93.7$ per cent.

Increasing Temperature of Radiators

In a vacuum heating system in which good circulation is obtained with 1 lb. back pressure, would the radiators supply more heat if the back pressure were increased to 3 lb.? The steam is supplied by the exhaust from pumps and live steam reduced from 110 lb. boiler pressure. *E. M.*

By increasing the pressure there would be greater activity of circulation with higher temperature and more heat would be obtained from the radiators. The temperature of steam at 1 lb. gage is about 215 deg. F. and at 3 lb. gage it is about 221 deg. F., or 6 deg. higher, and it is probable that there would be the same increase of radiator temperature with 2 lb. higher pressure at the vacuum pump.

[Correspondents sending us inquiries, should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

A new slant on things observed in and out of the power plant

What Happens and Why?

Falling Steam

A FALLING body gains velocity at the expense of the potential energy represented by its height. Steam expanding through a turbine nozzle likewise acquires velocity at the expense of part of the heat it contains at the start.

The analogy can be carried further. One B.t.u. equals 778 ft.-lb. This being so, an expansion of steam that reduces the heat one B.t.u. per pound should give the steam the same velocity as would be acquired by a body falling 778 ft. This relation actually holds true, assuming perfect expansion on the one hand and on the other a body falling in a vacuum.

The expansion of steam can best be pictured on a Mollier diagram, such as is shown in skeleton in the left half of the accompanying drawing. Perfect expansion, corresponding to a body falling in a vacuum, is represented by a vertical line. The right half of the drawing represents space above the earth's surface, the vertical scale being such that one B.t.u. equals 778 ft., or one mile equals 6.79 B.t.u.

Now consider steam expanding from dry saturation at 500 lb. (absolute) to 15 lb. as shown by the line *A* (left). The fall is 1,193 B.t.u. — 945 B.t.u. = 248 B.t.u. The velocity acquired is figured by the formula: Velocity (ft. per sec.) = $224\sqrt{\text{heat drop}} = 224\sqrt{248} =$ 3,530 ft. per second.

Turn to *A* on the right. The corresponding fall of a solid body is 36.6 miles. The formula for velocity (in a vacuum) is: Velocity = $584\sqrt{\text{fall in miles}} = 584\sqrt{36.6} = 3{,}530$ ft. per second.

Again, the lines *B* (left and right) show that expansion from 250 lb. and 500 deg. to ½ lb. in a single nozzle gives a velocity of 4,480 ft. per second, the same as a body falling 59 miles in a vacuum.

Such a velocity is too great to be handled efficiently by one turbine wheel. Hence the turbine is split up into pressure stages. Suppose the total drop of 400 B.t.u. is divided up into eight drops of 50 B.t.u. each. Then the velocity leaving the first nozzle is 1,585 ft. per second. This is used up by the first wheel before the steam passes to the second nozzle, where it again acquires a velocity of 1,585 ft. per second and so on through the turbine. The line *C* at the right shows an equivalent staging for the falling body, it being assumed that some machine brings the falling body to rest after each fall of 7.37 miles.

In practice turbine designers must make large allowances for frictional and other losses, just as the friction of the air must be allowed for in connection with falling bodies.

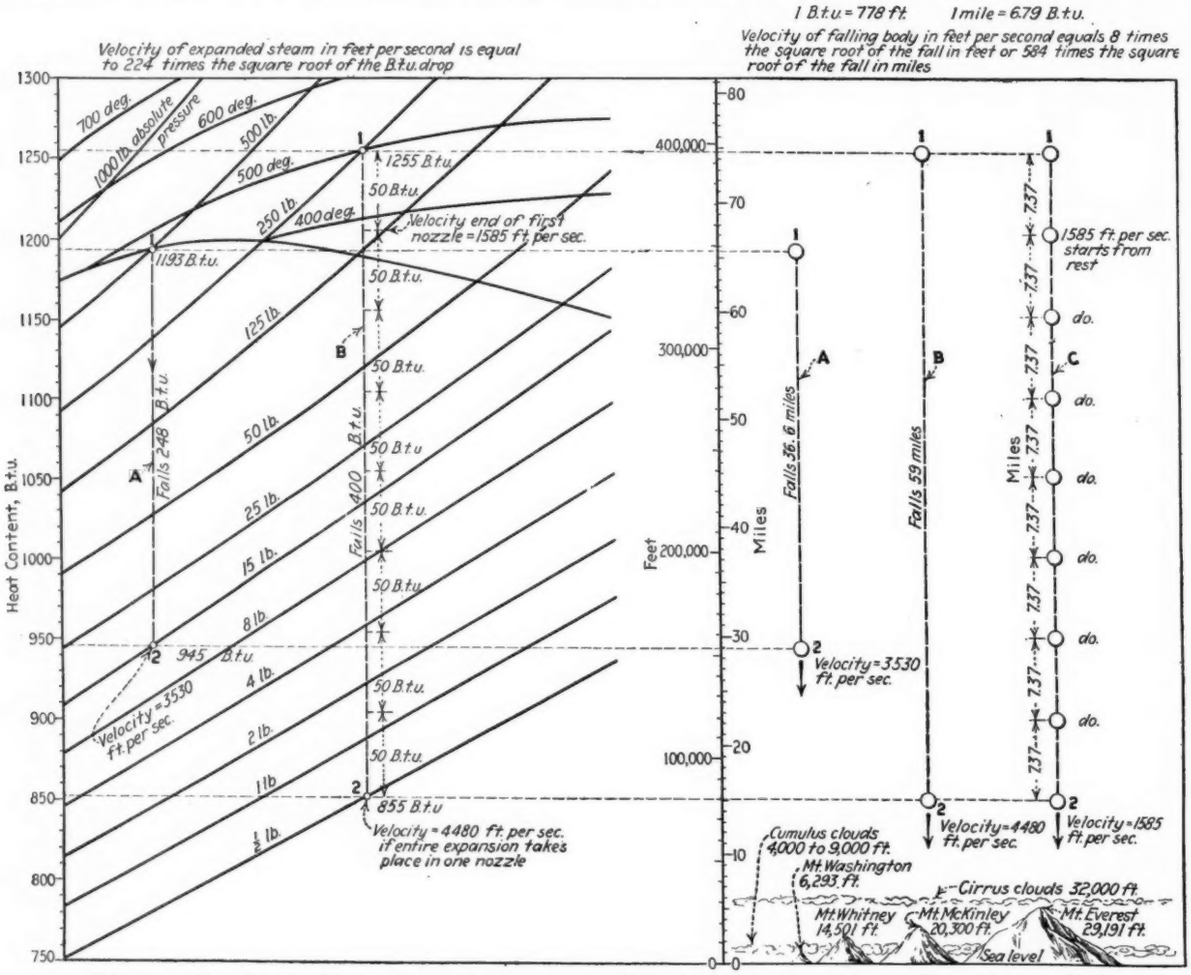

1 B.t.u. = 778 ft.
1 mile = 6.79 B.t.u.
Velocity of expanded steam in feet per second is equal to 224 times the square root of the B.t.u. drop
Velocity of falling body in feet per second equals 8 times the square root of the fall in feet or 584 times the square root of the fall in miles
Heat Content, B.t.u.
700 deg.
1000 lb. absolute pressure
600 deg.
500 lb.
500 deg.
250 lb.
400 deg.
125 lb.
50 lb.
25 lb.
15 lb.
8 lb.
4 lb.
2 lb.
1 lb.
½ lb.
1255 B.t.u.
50 B.t.u.
Velocity end of first nozzle = 1585 ft. per sec.
1193 B.t.u.
945 B.t.u.
Falls 248 B.t.u.
Falls 400 B.t.u.
Velocity = 3530 ft. per sec.
855 B.t.u.
Velocity = 4480 ft. per sec. if entire expansion takes place in one nozzle
Feet
Miles
Falls 36.6 miles
Falls 59 miles
Velocity = 3530 ft. per sec.
Velocity = 4480 ft. per sec.
Velocity = 1585 ft. per sec.
1585 ft. per sec. starts from rest
7.37
do.
Cumulus clouds 4,000 to 9,000 ft.
Mt. Washington 6,293 ft.
Cirrus clouds 32,000 ft.
Mt. Whitney 14,501 ft.
Mt. McKinley 20,300 ft.
Mt. Everest 29,191 ft.
Sea level

Diagram showing striking analogy between expanding steam (as shown by Mollier chart at left) and falling bodies (right)

Operating Requirements of Power-Plant Auxiliary Equipment

IN ORDER to learn the trend of present-day practice in driving auxiliaries in central stations having units of 20,000-kw. capacity and larger, information was obtained by a questionnaire, sent out through the Heat-Balance Subcommittee of the National Electric Light Association, Prime Movers Committee, concerning nearly all the modern large stations. This information has been reduced to tabular form and published in the 1924-25 serial report of the Electrical Apparatus Committee. Replies were received from 33 stations, but complete answers were not obtained in each case. The following is an abstract from the report.

Boiler-Feed Pumps

Modern boiler-room practice will not permit the interruption of the supply of boiler-feed water for a period longer than one minute on the average, unless the load is immediately dropped. In some cases where boilers are being operated at their maximum capacity, an interruption of the supply of feed water for even one minute could not be permitted. Necessarily, then, the feed-water pumps must be so arranged that there will be an unfailing supply of feed water regardless of disturbances in the power supply for the pumps.

Some of the large central stations have all the boiler-feed pumps steam driven. Others have motor-driven pumps to obtain the economies they give, but with sufficient capacity in steam pumps available to carry the full load if the electric power supply fails. There are some that have all motor-driven pumps with considerable reserve capacity, and in addition have the power supply carefully safeguarded. For example, of 28 central stations investigated, 21 have steam pumps in whole or in part and only seven have motor-driven pumps alone.

Where motor-driven pumps are used, most central stations have variable-speed motors. With variation of load on the plant the only alternative to the use of a variable-speed motor is to throttle the feed line to the boilers. This raises the pressure on the pump, causing increased wear on the pump impeller with consequent loss of efficiency and increased maintenance of the piping system. For average conditions a speed range of 20 per cent in 12 steps appears to be sufficient.

Circulating Pumps

Circulating pumps in most central stations must operate continuously if service is to be uninterrupted. In a few plants water is available under sufficient pressure so that circulating pumps are not needed, but this is not the usual case. Ordinarily, the load on a generating unit cannot be maintained if the supply of circulating water fails. The longest permissible interruption is commonly that required for automatic throwover equipment to change from one source of electric power to another or, in some cases, the time required to start automatically a stand-by unit. Such devices should be designed to function within 15 seconds or less.

There are a few plants having no duplication of circulating pumps. A more common scheme is to use two motor-driven pumps, both of which are required to operate the unit at full capacity. Other plants have a portion of their circulating pumps steam driven or duplex driven, to permit starting the plant readily after a shut down, where no tie lines are available.

Where electric drive is used, somewhat more than half of modern stations have variable-speed motors with an average range of 33 per cent in eight or ten steps. The maximum speed range is 50 per cent and the maximum number of steps is 22—not in the same plant, however.

Condensate Pumps

Under usual circumstances it is feasible to interrupt condensate pumps slightly longer than boiler-feed or circulating-water pumps. Average conditions will permit them to be interrupted for about three minutes with full load on the turbine, although some operators do not care to risk a stoppage longer than the time to change automatically to a stand-by source of power or stand-by machine. Most plants have duplicate pumps of full capacity, all motor driven for the most part, though there are some cases where one of the two pumps is steam driven. This latter condition aids in starting a plant from the cold state or after a shutdown, if the plant is isolated. Constant-speed motors are generally used.

Air Pumps

Air pumps do not ordinarily need as much insurance against outage as the auxiliaries described previously. However, the average time of interruption that can be allowed is six or seven minutes. If a condenser is tight against air leakage, it probably can stand as a maximum an interruption of its air pump for thirty minutes before the vacuum is seriously affected. The need, therefore, for uninterrupted service of the air pumps does not seem to be considered as great as for the pumps previously discussed, and many plants have no duplicate air pumps. A slightly larger number use duplicate air pumps, each with full capacity, in a few cases, one being steam driven, this latter sometimes being a steam-operated air ejector.

As with condensate pumps, constant speed motors are generally used. In the cases where variable-speed motors are utilized, the speed range averages 50 per cent in 18 steps.

Forced-Draft and Induced-Draft Fans

Under ordinary conditions boilers cannot be forced to their maximum output unless the fans are in operation. Studies of existing plants show that, on the average, forced-draft fans can be interrupted for 1½ min. and induced draft fans one minute, without causing trouble. When there is no demand for steam, on account of interruption to generator output, these auxiliaries may stay shut down during such an interruption. In fact, some engineers consider an arrangement that accomplishes this a desirable plan.

Since it is usually difficult to install duplicates, some plants have the forced-draft fans discharge into a header supplying all furnaces. In other plants spare motors are carried to replace defective ones.

Variable-speed motors are generally provided with an average speed range of slightly more than 50 per cent. The average number of steps is 12 for forced-draft and 17 for induced-draft fan motors. The difference in these figures is apparently incidental.

Stokers

It is essential that stokers operate continuously if full load is to be carried without interruption. Like the fans, it

PRACTICE IN DUPLICATION OF POWER-HOUSE AUXILIARIES

	No. Duplications	Two Equipments; Motor Driven, Each Full Capacity	Two Equipments; Motor Driven, Reduced Capacity	Two Equipments; One Motor, One Steam, Each Full Capacity	Two Equipments; One Motor, One Steam, Reduced Capacity
Boiler-feed pumps*	0	5	0	12	2
Circulating pumps	4	4	15	1	3
Condensate pumps	3	20	0	8	0
Air pumps	10	12	0	2	0
Forced-draft fans	15	4	4	1	0
Induced-draft fans	19	1	3	0	0
Stokers	19	5	0	1	0
Clinker grinders	18	0	0	0	0
Service pumps	4	13	2	4	0
Air compressors	11	13	4	0	0
Coal crushers	13	14	1	0	0
Coal conveyors	12	14	1	0	0
Ash conveyors	10	9	1	0	0
Pulverized-fuel feeders	8	1	1	0	0
Pulverized-fuel blowers	7	2	1	0	0

*Two stations reported all boiler-feed pumps installed in duplicate, each full capacity.
One station reported all steam pumps installed in duplicate, each reduced capacity. Three stations reported the use of all steam-driven pumps but submitted no data regarding duplication.

may be somewhat of an advantage to have stoker motors shut down in case of a general interruption and consequent dropping of load. However, where load is to be carried, an interruption to stoker motors must not last longer than 3½ min. on the average.

It is usually not advisable to duplicate stoker motors unless it is desired to install line shafting, clutches, etc. Sufficient boilers are generally installed and kept in service, so that the overload capacity will permit an interruption of a given stoker motor on an individual boiler without seriously affecting the operating conditions.

Variable-speed motors are the rule. The speed range is considerable, averaging 80 per cent in 17 steps.

Clinker Grinders

Clinker grinders come in a class of auxiliaries that usually do not require continuous operation to keep the plant in service. Under average conditions outages of from 30 to 40 min. can be allowed. In some cases this can be extended to an indefinite period. Many plants do not have any such devices installed. For these reasons there is usually no duplication of equipment.

Variable-speed motors are utilized for the most part. Average speed range is 75 per cent in about 10 steps.

Service Pumps

The need for continuity of operation of service pumps varies widely with local conditions. Sometimes city water supply is available under sufficient pressure to give satisfactory service. In other plants tank capacity is the controlling factor. Allowable time of interruption is, therefore, indefinite. However, there are plants so arranged that these pumps must be always available, especially for fire service, and for this reason partial capacity in steam-driven pumps is often installed. Under average conditions a 20- to 25-min. interruption is allowable.

It is customary to drive these pumps at constant speed, oftentimes automatically controlled by tank floats. In a few cases where variable-speed motors are used, the speed range averages 25 per cent in 17 steps.

Air compressors are used mainly in station maintenance and while some duplication is ordinarily needed, the time of allowable outage is indefinite. Constant-speed motors are the rule.

Coal Crushers, Coal and Ash Conveyors

These devices render service that can be conducted intermittently. The coal-handling machinery is usually installed with sufficient margin of capacity so that 24- to 48-hr. supply of crushed coal can be put in the bunkers in an 8-hr. shift. In about half of the plants investigated, no duplicate apparatus, other than spare motors and repair parts, was carried. The same general statements hold for ash-handling machinery. In many cases both coal and ashes may be handled manually, if necessary.

Pulverized-Fuel Feeders

The supply of pulverized fuel cannot be interrupted if the load is to be carried. One minute would seem to be the maximum allowable outage. However, it is common practice not to duplicate this apparatus since usually a large number of feeders per boiler are installed, which precludes the necessity for duplication of motors operating the feeders. In the single-burner system, this of course does not hold good.

Variable-speed motors, having a wide variation of speed with a large number of steps, are the rule. A smooth variation in small steps is highly desirable.

Pulverized-Fuel Blowers

These come under the same general classification as pulverized-fuel feeders except that the time of allowable outage averages one minute and constant-speed motors are used in about the same number as variable-speed motors.

Water-Cooled Furnaces*

Water-Cooled Walls Favored Over Hollow Wall Construction for Stoker Furnaces and with Pulverized Fuel and Preheated Air Considered Essential

By H. D. Savage

NOTWITHSTANDING the excellent work that has been done in the investigation and development of special refractories, furnace materials have not been keeping pace with the higher duties placed upon boiler furnaces owing to higher settings, higher ratings and higher efficiencies. Higher furnace temperatures in the beginning led to the development of ventilated blocks, of which there are a number of different types to be had. The more recent and complete developments, however, cover hollow wall refractory furnaces, steam-cooled walls and water-cooled walls.

While the hollow-wall furnace was a tremendous step forward, its application is more practical with powdered fuel than with stokers, so that it meets limitations. The steam-cooled walls may be applied to any type of firing, but naturally the amount of cooling obtained from this source must be limited, as the area possible to expose in the furnace is governed by the amount of superheat required, and up to the present time results obtained would indicate that this method of cooling is not yet out of the experimental stage. The completely water-cooled furnace or a combination of water-cooled and refractory furnace would seem to present the greatest possibility for future interest.

The Fin-Type Furnace

One type of water-cooled furnace, known as the fin furnace will be discussed. This furnace has been applied to both stoker and pulverized-fuel installations, and while accurate data covering the net effect of such walls on capacity and economy are too meager from which to draw conclusions, there have been a sufficient number of installations made to discuss it from a practical operating point of view. Three water-cooled furnaces over stoker fires have been in operation at the Hell Gate plant of the United Electric Light & Power Co. for over a year, and six similar furnaces in connection with pulverized-fuel firing have been in operation for several months at the Sherman Creek plant. These nine units have been in regular service since their installation, and no unusual operating difficulties have developed.

When the finned tubes were applied at Hell Gate, prophecies were made as to the burning off of the fins, the erosion of the tubes and the reduction of efficiency through too much cooling in the furnace. None of these prophecies has been fulfilled. The tubes and fins show no erosion, the corners of the fins being just as true and square as when originally applied. The boilers have been in operation up to approximately 600 per cent of rating, and efficiencies have been published from tests[1] of these boilers, which show as high as any that have been produced in the country.

Welding the Fins to the Tubes

Welding of the fins onto the tubes makes a complete bond, so that the transfer of the heat through the fins and tubes is almost equal to the transfer through the tube itself. While no data are available at the present time covering actual results obtained, some tests are now being planned which will furnish data covering velocity, absorption, radiation, etc. Tests recently made on a water screen at Cahokia indicate an absorption on the horizontal tubes of approximately 80,000 B.t.u. per sq.ft. and on the vertical side tubes of close to 75,000 B.t.u. per sq.ft. It has not been found that the capital expenditure required for fin furnace construction is greatly in excess of the latest type of refractory furnaces. If credit is given for the additional heating surface gained, the cost chargeable to the furnace will be slightly less than with other methods.

Another tendency at the present time is toward preheating combustion air. Pulverized-fuel firing in combination with air preheaters makes possible high ratings and produces high temperatures in the furnace. With water-cooled walls installed under such conditions, the units may be kept on the line for long periods without any more liability of shutdowns than is caused by the boiler itself under present conditions.

It has been suggested that too much cooling may be obtained. All of the operations so far show that there are no disadvantages from cooling, and it is known from experience that completely water-cooled furnaces, such as locomotives and Lancashire boilers, are

*Abstract of paper read before Chicago Section of the American Society of Mechanical Engineers, January 14, 1925.

[1]For a description of these furnaces and results of tests, see *Power*, Sept. 2, 1924, pp. 354-58.

used at high ratings with excellent efficiencies.

The high cost of boilers and accessories and the proved ability of modern firing methods to produce high ratings for long periods with high economy, have made obsolete former methods of rating of not more than a year ago.

This is strikingly illustrated in the case of a new station projected for the eastern part of this country, where the original figures made on the basis of underfeed stokers operating under the most favorable conditions, showed a necessity of forty-four boilers of approximately 15,000 sq.ft. heating surface each. The present figures revamped to cover pulverized-fuel firing, which has been adopted for this station, indicate a necessity for only thirty-two boilers of the same size.

The question has been raised as to the effect the welding of the fins might have on the strength of the tubes. Numerous tests have been made on finned and unfinned tubes, and it is found that there is practically no reduction in the strength of the tube due to the welding of the fin. A hydraulic test was made recently on a 4-in. tube 4 ft. long, on 2 ft. of which fins had been welded and the other 2 ft. left plain. The pressure was run up to 6,000 lb. per sq.in., when a leak developed in the end plug, but no bulge or rupture occurred anywhere in the vicinity of the fins. The standard rupture test for a tube of this type is 6,200 pounds.

Discussion

In the discussion following the presentation of Mr. Savage's paper, H. C. Heaton, of Sargent & Lundy, favored protection of the refractory material in boiler settings. They had tried to work out the problem in a little different way at Calumet Station, in that a water screen without the fins had been applied, and thus far over a period of nine months' operation no trouble had been experienced from burning out of the tubes or damage to the brickwork behind the tubes.

C. E. W. Clarke stated that two years ago in the Allegheny County steam-heating plant, a large boiler, pulverized-fuel fired, had been installed and owing to certain operating conditions was equipped with a water wall consisting of plain tubes inserted in the firebrick on 10½-in. centers. Owing to light load on the boilers through the summer months, it was felt that an air-cooled wall would have received severe punishment from the light flow of gases at high temperatures. The installation met all expectations and is now running through its second winter. At Colfax two pulverized-fuel boilers with preheated air and water-cooled furnaces have shown some serious erosion effects, which will be corrected by fin furnaces. With the use of preheated air it was the speaker's opinion that the cooling of the walls artificially other than by air was absolutely necessary.

In reply to a question by John Hunter as to the main combustion temperatures obtained in these large boilers with cooled walls, Mr. Savage showed a slide that had been prepared from data taken from the Oneida Street Station. The highest temperature shown was 2,700 deg. F. and the lowest, in the vicinity of the front wall where the excess air was admitted, about 1,500 deg. These temperatures were again verified at the Bruno Island plant, where a maximum temperature of about 2,800 deg. F. was obtained.

Joseph Harrington inquired whether anything had been done toward the greater utilization of the direct radiant heat from the incandescent fuel and whether determination by the author had been made on the reduction of side-wall radiation.

In reply reference was made to some determinations on a screen at Cahokia to see what was being done by radiation and by contact and also to elaborate tests to be made at the Sherman Creek plant, where the tube or fin part was being connected to a separate drum. These data were not available, but at Hell Gate considerable saving had been noticed in the back and front walls due to the absorption of the radiated heat by the screens.

In commenting on the Hell Gate installation W. E. Caldwell, of the United Electric Light & Power Co., said it was necessary only to provide insulating material between the outside of the tubes and the air. On the first installation the walls were partly bricked up, but in future the brickwork probably will be eliminated. Attention was called to the fact that all the work was done on the fire side of the tube, the fins conducting the heat received by radiation to the rear portion of the tube.

Efficiency Test of Multi-Exhaust Blades

In order to determine the efficiency of the multi-exhaust blades on a 7,000-kw. turbine, careful tests were made by the Metropolitan Vickers Electrical Company, Ltd., of England, the builder. This was a 12-stage machine operating at 3,000 r.p.m., 190 lb. gage, 180 deg. F. superheat, 28.63 in. vacuum.

The blade row at the twelfth stage was divided by partitions into two steam belts, the outer of which discharged in the exhaust passage and the inner of which was discharged through stationary steam vanes to another row of moving blades representing the thirteenth disk, where it expanded to the same exhaust pressure as the outer steam belt. The multi-exhaust, or Bauman, principle was explained in the May 15, 1923, issue.

Tests were made both with the two exhaust rows removed and also with them in place, holding the load practically at 7,000 kw. and varying the vacuum, but with as nearly constant initial steam conditions as possible.

The turbine was designed for an internal efficiency of 78.7 per cent at the designed vacuum of 28.63 in. with a load of 7,000 kw. With the two exhaust rows of blading removed, the rated vacuum gave only 74.4 per cent efficiency for the entire turbine, representing a difference in steam consumption of 5.6 per cent.

However, efficiency without exhaust vanes improved so much at lighter vacuum that 78.7 per cent was obtained with 27.8 in. This latter effect is due to less leaving loss with less expansion at the exhaust vanes, but it also represents less total work obtained on account of the expansion being to a lower vacuum.

With the addition of the exhaust blading the rated efficiency of 78.7 per cent could be carried at 28.63 in. Also, the lower vacuum of 27.8 was more efficiently utilized than without the exhaust blades, as with them it amounted to 80.5 per cent. The efficiency of the exhaust blades themselves was about 73 per cent, as not being charged with leaving and exhaust losses. Complete description and tabulations were published in the Aug. 22, 1924, issue of *Engineering* (London).

Blanked Flange Fails in Boiler Test

That boiler manufacturers should provide standard blanks wherever required during a hydrostatic test, and that inspectors should see that sufficient bleeders are provided to release all trapped air before applying such a test, is evidenced by an accident as described by John S. Spicer, chief of Accident Investigation Section, Bureau of Inspection, in the December issue of *Labor and Industry*.[1]

In closing up the exit pipe connections to the boiler, etc., in preparation for a hydrostatic test, a cast-iron blank which was not designed for such a purpose, was utilized. The web of this flange was $\frac{13}{32}$ in. thick, but was reinforced with stiffening ribs to such an extent that it probably would have withstood the test pressure successfully except for the fact that a portion of each rib was machined off in order to make room for bolt holes. The article does not state the size of the pipe opening that this covered.

The boiler was of the four-drum cross-tube type, with a heating surface of 6,980 sq.ft. and a working pressure of 207 lb. steam. The hydrostatic test was at one and one-half times the working pressure, or 311 lb. per sq.in.

It is customary, besides blanking the opening, to provide also a ¾-in. valve at the highest point of the boiler for the escape of the air. Such a valve was connected by a pipe 4 ft. long to the center of the hub on the blank on No. 1 drum. The valve was left open until the water flowed from the valve freely, appearing that air had completely escaped, and then closed. When the test pressure reached 250 lb. per sq.in., the flange ruptured.

Sufficient air had evidently been trapped in the boiler, unknown to the person making the test, so that the rupture of the flange allowed it to escape with great concussion and explosive effect. The noise startled a structural steel worker who was at work on a 12-in. I-beam about 10 ft. away, and who lost his balance, falling to the floor 35 ft. below with fatal results. The need of manufacturers' furnishing equipment for testing, and of inspectors' conforming rigidly to a proper testing routine is thereby evidenced.

[1]Published by the Commonwealth of Pennsylvania, Department of Labor and Industry, Harrisburg.

Industrial Marketing Keynote of McGraw-Hill Convention

HOW industrial and business papers may help to cut waste in sales and distribution and to assist in developing economic markets for the manufacturer, was the general topic of discussion of a three-day convention of the business and editorial representatives of the fifteen McGraw-Hill publications, which closed Friday night, Jan. 30, with a dinner at the Hotel Pennsylvania, New York.

Among the guests who spoke at the dinner were Julius H. Barnes, past president of the United States Chamber of Commerce; Fred I. Kent, vice-president of the Bankers Trust Co.; David Sarnoff, vice-president and general manager of the Radio Corporation of America, and Fred. M. Feiker, vice-president of the Society for Electrical Development. Short addresses were also made by Malcolm Muir and E. J. Mehren, vice-presidents of the McGraw-Hill Company. It had been hoped that Secretary Hoover would be present, but being unable to attend, he stressed in a letter, which was read at the dinner, the importance of industrial and business papers as leaders in economic and industrial thought.

Industrial Progress of U. S.

Mr. Barnes spoke on the industrial progress in the United States. In the relatively short period of its existence, this country with only six per cent of the World's population has grown to the unique position of producing fifty per cent of the World's copper, iron, lumber and oil, ninety per cent of the automobiles and forty-two per cent of the shoes. It has one-half of all the railroad mileage and three-quarters of the telephones and telegraph. Tracing this productivity to the development and utilization of power, Mr. Barnes pictured the growth in this connection from one-half horsepower per worker fifty years ago to four horsepower per worker today. Viewed from another angle, one can almost place the status of a nation by the figures of newsprint consumption. For instance, Russia's consumption of newsprint is six pounds per capita, Japan's twelve, Germany's fifty-two, Great Britain's seventy-six and the United States one hundred and fifty.

All this growth has resulted under private initiative, but one of the chief problems today is the growing complexity of the relations between Government of established authority and the private processes of industry and private lives. The intense individualism in America cannot be restored to its old shape, but it is possible so to align the relationship of government and the private lives of our people that we can preserve that individual impulse, resourcefulness and initiative on which the whole progress of America has been based. In this connection Mr. Barnes expressed the belief that industrial and business papers, chambers of commerce and like bodies, which aim to express and crystallize the opinion of the organizations and industries they represent, will find some way to guide government in arriving at sane and constructive solutions in the growing perplexity of these questions.

A BIG change has come in the spirit of American business and for this change you are in part responsible. I mean the change from rule of thumb and *laissez faire* to scientific determination of facts and programs of action based on facts. The business press is probably the greatest force in making industrial opinion. The schools and colleges have an important place, the trade associations can do much in the fields of production and distribution, the government bureaus which keep in contact with business can help to promote sound leadership in industrial and economic thinking. All have an important place, but the business press and technical journals are in a unique position and have a unique opportunity. I believe that no organization of technical publications have come nearer to living up to this opportunity than the McGraw-Hill publications under the leadership of Mr. James H. McGraw.

The thought that I have in mind is that your great group of journals cannot only recognize and support sound industrial leadership, you can also initiate it. The field of your opportunity is practically limitless.—*Letter from Secretary Hoover.*

Mr. Kent discussed the European situation particularly with references to finances, pointing out conditions in Germany during the period of the depreciated mark. He also told of the difficulties being experienced by the French government in balancing its budget and touched upon some features of the French debt to the United States. He believed that the ultimate solution of this indebtedness rested upon a business survey of the industrial situation in Europe.

The subject of Mr. Sarnoff's address was opportunity. "There are no rules whereby anyone may recognize an opportunity, but if one keeps on looking and never ceases that occupation he will find it," said Mr. Sarnoff. Referring to radio as an illustration, he cited how Professor Hertz had looked at the opportunity for transmitting magnetic waves from one place to another without the aid of physical agencies and therein had in his grasp all that constitutes the fundamentals of radio. But it remained for a young man by the name of Marconi, then only eighteen years old, to see the opportunity and apply the results of Hertz's researches to the needs of mankind. "Radio is a young industry and an industry of young men," said the speaker; and the latter fact in his opinion is responsible for the tremendous developments that have taken place in this field during the last three or four years. He expressed the opinion, however, that we are only at the threshold of the most important scientific developments and inventions, not only in the field of radio, but in the field of industrial electricity as well.

Speakers Stress Economic Selling

Prominent American industrialists took part in the sessions of the convention itself. Their talks followed closely the lines laid down for discussion, and each speaker stressed important phases of the effort of the McGraw-Hill Company to develop to the maximum its program of help to industry in promoting economic and efficient selling and distribution methods. Facts brought out in the company's nation-wide survey of the buying habits of industry repeatedly formed the basis of discussions.

In the first session of the convention, which opened Wednesday morning, W. L. Batt, president of the S.K.F. Industries, Inc., and P. L. Thompson, advertising director of the Western Electric Co. and a past-president of the Association of National Advertisers, spoke. Mr. Batt, who had the subject, "Creative Selling," made clear, among other things, the definite needs industry has for help, information and guidance from the industrial and business press. Mr. Thompson, who had as his subject "The Publisher's Representative from a Buyer's Point of View," showed the importance of co-operative effort between the publication and the advertiser, so that the advertiser will realize to the fullest extent benefit from the broad knowledge of industrial fields possessed by the industrial and business paper.

Pulverized Coal Displaces Oil In Small Plant

The Newburyport Gas & Electric Co., serving Newburyport, Mass., and vicinity, is completing the installation of the first pulverized coal unit and has purchased a second unit.

This plant consists of six 3,500-sq.ft. boilers. For the last five years fuel oil has been used with considerable satisfaction. The differential in favor of coal has led the general manager of that company, J. Lee Potter, to proceed with the installation of pulverized coal on two boilers, and it is expected that the other four boilers will be equipped as soon as the first two are in operation. It is expected that the use of pulverized coal will result in saving approximately $1,000 per boiler per month. The furnace and arrangement of equipment is being designed and supervised by Roderick D. Donaldson, consulting engineer, of New York.

Muscle Shoals Conferees in Troubled Waters

In their efforts to reach an agreement on the Muscle Shoals bill the conferees for the Senate and the House find themselves between Scylla and Charybdis. If they do not make the fertilizer requirements less drastic, they realize that there is no hope of securing private bids. On the other hand, if they modify the fertilizer requirements, they face the rejection of their report. Nevertheless, their difficulties are not regarded as insoluble. One thing is certain, however, no legislation can be made satisfactory to those who dabble in fertilizer manufacture in order to get the power.

The question is turning on how much power subsidy will be required to interest those who would undertake the manufacture of a certain amount of fertilizer. It is believed that no one is willing to make as much fertilizer as is called for by the Underwood bill even with all the subsidy that they could hope to realize from the power. If the power payment should be reduced to 4 per cent on the cost of the dam, less the $17,000,000, and should the payment for power during the first six years be no more than $200,000 per year, as proposed, it would subsidize the fertilizer production to the extent of $14,000,000 for that period, it is believed.

At the request of the President the conferees called in the Secretary of War and the Secretary of Commerce and heard their views on the legislation.

It is estimated by the *European Commercial*, a Vienna publication, that the country now included in Czechoslovakia mined 23,000,000 tons of coal in 1913. In the year after the war, 1919, this stood at practically 17,000,000 tons. The peak year of the post-war period was in 1922, with 21,500,000 tons. From this it has dropped steadily; in 1923 it only just passed 16,000,000, and this year the production will probably not exceed 15,500,000 tons. Home consumption totals about 14,500,000 tons, which leaves only 1,000,000 tons surplus to export as against the 7,000,000 of 1921.

Soft Coal Operators Against Senator Oddie's Bureau of Coal Economics

Lawmakers Surprised at Attitude of Operators—Senator Oddie Against Government Ownership

ANY doubt as to the attitude of coal operators toward Senator Oddie's proposed Bureau of Coal Economics, a subdivision of a proposed Department of Mines, was dispelled at the meeting in Washington of the Government Relations Committee of the National Coal Association, on Jan. 29.

The coal operators feel that the federal government is justified in supervising businesses when either a natural or artificial monopoly exists or when such a step is necessary to conserve a natural resource facing early exhaustion. They think that the bituminous coal industry does not belong in either of these classes.

On Capitol Hill the lawmakers are at a loss to understand how the coal operators have failed to catch Senator Oddie's spirit. The metal mining industry long has known, as have those coal operators who have made his acquaintance, that he is a friend of the mining industry. He is opposed to government ownership and operation. He is a Republican and is in thorough sympathy with the party's policy, which stands for a minimum of government in business.

No Desire to Regulate Coal Production

When a man of such impulses and with such viewpoints has a suggestion to make, his associates are at a loss to understand why the coal industry does not regard him as worth listening to, even if it does not accept a legislative suggestion which was put forward avowedly for study and discussion. Senator Oddie has stated repeatedly that his only purpose is to promote the general welfare, including that of the coal industry. He has no desire to regulate the production or distribution of coal. He thinks Congress and the public should have essential information about it, but he contends that there is no more regulation in his conception of a Department of Mines than there is in the Department of Commerce or the Department of Agriculture. He hopes to have done for mining what Secretary Hoover is doing for manufacturing and what the Secretary of Agriculture does for farming. He fails to see where his Bureau of Coal Economics is inconsistent with this purpose. If regulation lurks in his bill, he fails to see it.

Increased Federal Activities

It was pointed out at the meeting of the Government Relations Committee that perhaps never before were as many plans under consideration for increased federal activities in the field of industry as at present. The consensus of opinion was in opposition to this trend, which in most cases results in interference with industry by the government and places further burdens on the shoulders of coal producers.

The fact that the Federal Trade Commission, after having lost its contention before two courts in the Maynard case, should embark on another fishing expedition in connection with its report on the wealth of the country was roundly condemned. Great surprise was expressed that the Commission should send out a questionnaire to coal companies in an effort to ascertain the acreage and value of coal lands owned and leased, with an estimate of the quantity of recoverable coal and its value, together with a statement of the amount of coal mined in the years 1918 and 1923, when the report of the Engineers' Valuation Committee to the Harding Coal Commission was available. Moreover, the Senate adopted the resolution calling for the report on wealth under the distinct understanding that this simply was to be a compilation of information already in the hands of various government agencies.

William Cramp Company Wins Valve Suit

The United States Circuit Court of Appeals for the Sixth Circuit has affirmed the decision of Judge Westenhaver in the United States District Court for the Northern District of Ohio, upholding the Johnson patent No. 1,030,890, owned by the William Cramp & Sons Ship & Engine Building Co., Philadelphia, and holding that the patent is infringed by the balanced valve manufactured by the Wellman-Seaver-Morgan Co., of Cleveland.

The type of valve involved was that installed by the I. P. Morris Department of the William Cramp & Sons Ship & Engine Building Co., at Niagara Falls and other hydraulic power plants throughout the country for controlling the flow of penstock water to the turbines. The defendant's valve was alleged to differ from the valve of the Johnson patent in exhausting a large part of the pressure to atmosphere instead of into the conduit, and in other particulars. The District Court had held these differences to be immaterial, and in its opinion, said:

"In my opinion this patent embodies invention of a high order. It is not too much to say that it has produced a new art in conduit or in penstock valves where the valve must open or close under high pressure."

The Circuit Court of Appeals in its opinion says:

"We accept and approve in all substantial respects the disposition and treatment of the case by the District Judge."

In its finding of infringement the Circuit Court of Appeals further said:

"There is, therefore, reason for saying that the liberal, rather than the strict rule of equivalency, should be applied, and this in addition to the tendency to a liberal construction, demanded by the highly useful and novel general character of the invention."

Ford Advocates Government Operation of Shoals

Henry Ford, according to the daily press, has offered his co-operation and all the researches of the Ford company, in the form of knowledge and experience of its engineers, if the government will retain Muscle Shoals and operate the nitrate plant by the Army and Navy. Mr. Ford made public the following statement:

"I am no longer interested in taking over Muscle Shoals in accord with the original Ford offer which I made at the request of the War Department four years ago. However, I am willing to co-operate with the government in developing Muscle Shoals into a great nitrate plant and making cheap fertilizer for the American farmer.

"In my opinion the Shoals should be used for the production of nitrate and fertilizer. I believe that the government could itself keep Muscle Shoals and run it, not as a power plant, but as a nitrate plant, to help the farmers in peace and safeguard the country in war. The people of the United States spent $140,000,000 to create a government nitrate plant, not a power house. We should not lose sight of the original and biggest reason for Muscle Shoals being built.

"If the government keeps Muscle Shoals and operates the nitrate plant by the Army and Navy, I shall be glad to put at their service all that the Ford company has of knowledge and experience. Our engineers have been working for three years on the problem of making cheap nitrogen from the air for farmers. We believe we have discovered improvements on the present processes. We believe air nitrate can be made at a price that will materially reduce the cost of fertilizer on the farm.

"The Ford company will turn over to the government without cost the result of its research. We will lend the men to help build up an efficient organization to run the Shoals. As a citizen's duty we worked with the Army and Navy during the war. We are ready to give the same co-operation to the government in aid of the farmers now, cost free to the government.

"Our open offer, made at government request, was based on public service principles, with a view to developing, maintaining and turning back to the government a great public utility and defensive asset. This cannot be done under the system of 'private profit only' that now rules business.

"It is a mistake to say that the government cannot run the nitrate plant as well as any private party. This is the very kind of business the government ought to engage in. Electrochemical methods of air nitrogen fixation do not require great forces of employees. It is a straight job of letting the forces of nature work for you. The government has as good men as there are in this field. We talked with some of them when we were figuring on the Shoals.

"If the government keeps Muscle Shoals and runs it for the farmers, I will help, so far as technical help goes just as much as I could have helped if I had taken the property over."

Ouachita River Plant Placed in Operation

Remmel Dam on the Ouachita River, was placed in operation by the Arkansas Light & Power Co. on Jan. 31, 1924. It will be connected with a 100,000-hp. steam station now under construction by the Louisiana Power Co. in the natural-gas field near Monroe, La., and with the system of the Mississippi Power & Light Co. serving twenty-five cities in Mississippi. The new plant will ultimately develop 24,000 hp., and represents an expenditure of $1,600,000.

The Remmel hydro plant is the first of three plants to be constructed by the company on the Ouachita River for the development of 125,000 hp. at a cost of $18,000,000.

Committee Reports Power Trust Resolution

No action has been taken by the United States Senate on the resolution proposing an investigation of the General Electric Co., on the ground that it monopolizes or controls electric light and power company business as we go to press. The resolution was returned to the Senate by its interstate committee in a greatly modified form, which was rather reluctantly accepted by Senator Norris, the father of the original motion.

The text of the resolution as reported out of the Committee on Interstate Commerce is as follows:

"Whereas, It has been alleged during the course of debate upon a bill relating to the disposition, operation, maintenance and control of the water-power and steam-power plants with their incidental lands, equipment, fixtures and properties, that a corporation known as the General Electric Co. has acquired monopoly or exercises a control in restraint of trade or commerce in violation of law, of or over the production and distribution of electric energy and the manufacture, sale and distribution of electrical equipment and apparatus. It is further

"*Resolved*, That the Federal Trade Commission be and it is hereby directed to investigate and report to the Senate to what extent the said General Electric Co. or the stockholders or other security holders thereof, either directly or through subsidiary companies, by stock ownership or through other means or instrumentalities, monopolizes or controls, the production, generation or transmission of electric energy or power which is produced by steam, gas or water power and report to the Senate the manner in which the said General Electric Co. has acquired and maintains such monopoly or exercises such control in restraint of trade or commerce, or in violation of the law.

"*Resolved*, Further, that the President of the United States be and he is hereby requested to direct the Secretary of the Treasury under such rules and regulations as the Secretary of the Treasury may prescribe to permit the said Federal Trade Commission to have access to official reports and records pertinent thereto in making such investigation."

Owen D. Young, chairman of the board of the General Electric Co., when asked about the resolution of inquiry into General Electric activities, proposed in the United States Senate, said the General Electric Co. has no objection to such an inquiry being made into its affairs.

"Burdensome and expensive as it is to a business organization, it is better than unfounded charges based on misinformation," he said.

"The proposed resolution, however, not only directs an inquiry into the shareholdings of the General Electric Co. and its subsidiaries, but also into the holdings in other companies of its individual shareholders and bondholders."

Oil Switch and Not Rat Caused Shutdown

At 6:50, on the morning of Feb. 2, an oil switch failed in the Fifty-ninth Street power house of the Interboro Rapid Transit Co., New York City, and caused a bad crippling of train service for about three-quarters of an hour.

The first report of this accident, as given in the newspapers, indicated that the trouble had been caused by a rat gnawing the insulation of one of the 30,000-kw. generators, causing a short-circuit of the machine and a destruction of its winding. This report has been denied by one of the company's engineers, who stated that there was nothing to indicate that the original trouble started from any such cause, and furthermore no damage was done to the generating equipment in the plant.

The failure of the oil switch caused a short-circuit of the system and tripped the generators in the power house off the system, which in turn shut down a number of substations. Although the trouble was cleared and the generators back into service in about 12 minutes, it required about one-half hour more to restore service to normal.

A.S.M.E. Codes Now Under Preparation

The American Society of Mechanical Engineers has now in course of preparation, Codes as follows: Boiler codes —"Rules for the Care of Boilers and Other Pressure Vessels in Service," "Rules for the Construction of Unfired Pressure Vessels"; Power Test Codes— "Fuels," "Steam Turbines," "Reciprocating Displacement Pumps," "Centrifugal and Rotary Pumps," "Displacement Compressors and Blowers," "Centrifugal and Turbo Compressors and Blowers," "Complete Steam Power Plants," "Condensers, Water Heating and Cooling Equipment," "Refrigerating Machines and Plants," "Evaporating Apparatus," "Locomotives," "Gas Producers," "Instruments and Apparatus," "Definitions and Values"; Elevators—"Safety Code for Elevators," "Rules for Elevator Inspectors"; Fluid Meters—Part II "Report of the Research Committee on Fluid Meters"; Miscellaneous Codes—"Standardization of Cast Iron Flanges and Fittings, 125 lb. Steam Pressure," "Standardization of Cast Iron Flanges and Fittings, 250 lb. Steam Pressure," "National Fire Hose Coupling Threads," "Standardization of Plain Limited Gages for General Engineering Work," "Code for the Identification of Piping Systems."

Two Big Generators for Japan

The International General Electric Co., according to press reports, has received an order from the Hayakawa Electric Power Co. of Japan for two 35,000-kw. turbo-generators and auxiliary equipment. The order is reported as involving about $900,000.

Another Big Power Merger Announced

The final steps were taken recently in a plan that will link together in one system a number of the large electric light and power companies operating in West Virginia, Ohio and Maryland. Consolidation of these resources in one superpower system will make one of the largest systems of its kind in the country.

A. M. Lynn, president of the West Penn companies, announced that a consolidation and unification of all the electric light and power companies of the West Penn system within the three states had been effected. This was done through the transfer of the properties concerned to the Monongahela West Penn Public Service Co. The properties and assets thus involved were of the Brooke Electric Co.; the West Virginia & Maryland Power Co.; the Parsons Electric Service Co.; the St. Mary's Power & Light Co., and the West Maryland Power Co.

Patent Office Needs New Building

The Committee on Patent Office Procedure, appointed some weeks ago by the Secretary of the Interior to make a study of the Patent Office methods and procedure, has been actively at work. At a recent meeting it came to some final decisions.

The essential difficulty with the Patent Office is the lack of adequate and well adapted space. The building in which it is housed was designed and built with the primary objective of displaying models of patents and as an industrial arts museum. In the early history of the Patent Office this building afforded fairly satisfactory office room, in addition to the space designed for museum purposes. However, the personnel has long since outgrown all working floor space with the result that desks and files have been put in the basement, attic and hallways. The building is intolerably crowded, notwithstanding that within a year some additional space has been obtained in the Land Office Building.

It was in light of the foregoing facts that the committee recommended that an effort should be made to have assigned immediately to the Patent Office such additional space in the Land Office Building as required for a number of new divisions and to provide for the probable growth during the next four or five years, and further that the federal government be urged to design, build and equip at the earliest possible moment a modern office building for the Patent Office, the building to be designed for the special needs of the Patent Office and of ample capacity to provide for the normal growth thereof.

New York Water Power Commission Advocates Immediate Development of St. Lawrence Power

Power Development Should Not Be Dependent on Navigation—Possibilities of More Diversion—Revision of Treaty Needed

OUT OF deference to Governor Smith's policy of State ownership and development of water power, the New York State Water Power Commission, in its fourth annual report submitted to the Legislature on Feb. 2, announced that it has continued to withhold approval of all applications of permits for private development. Twenty-five such applications had been received since the enactment of the law four years ago under the administration of Governor Miller.

The feature of the report is its recommendation for the immediate development of potential water power in the St. Lawrence River. The report says:

"The tremendous growth in the demand for electric power and the advance in transmission, has made it feasible to develop the St. Lawrence power at this time, whereas, at the time of the early studies such development was out of the question. No one desires water-power improvements on the river that cannot be adopted to the full utilization of power.

"Similarly no one desires water-power developments that do not conform to navigation requirements."

Discussing co-operation between the United States and Canada and the need of a new treaty, the report differentiates between the proposed developments and the navigation improvements such as the Great Lakes to the Sea waterway project as follows:

"The development of water power on the St. Lawrence River shall not be made dependent on navigation improvements, and development of power should be permitted to proceed at as early a date as feasible, leaving navigation improvements to proceed if and when determined upon.

"An early development of the St. Lawrence River power will effectively stop the belittling of the damages caused by the Chicago diversion for the reason that no use is made of the water."

The report emphasizes the possibilities of the development of the eighty-foot fall in the lower Niagara gorge as a means of equalizing the amounts of power derived from the American side of the falls with that developed on the Canadian side. The report estimates that 150,000 hp. could be developed there alone on the basis of 19,500 cu.ft.-sec. diversion from the Maid of the Mist pool.

Reference is made to the action of former Attorney-General Carl Sherman in withdrawing the suit against the United States Government to determine jurisdiction of the boundary waters between this state and the government and that Attorney-General Albert Ottinger expects to reopen this suit with a view to fixing the state's status definitely.

The report urges an adequate appropriation to defray the necessary expenses of defending New York State's rights in the matter of the Chicago diversion from the Great Lakes.

"New York's need for power is great, and any authorization for a diversion in excess of the amount required for navigation is strongly opposed," says the report.

X-Ray Apparatus Needed for Boiler Testing

The Boiler Code Committee of the Council of the A.S.M.E. recommended at its meeting in Washington on Jan. 15, that the American Engineering Council advocate the appropriation now before Congress which provides for a 600,000-volt X-Ray apparatus for Watertown Arsenal to test heavy materials.

Modern developments in X-Ray analysis has made it possible to find defects in materials and in jointed construction hitherto beyond detection without total destruction.

It is impracticable for even a large industry to support the laboratory and other apparatus necessary for the testing of heavy work. The limited number of applications to this kind of work in a single establishment would make the overhead per job prohibitive.

The availability of powerful apparatus of this kind and of a corps of trained and expert observers and operators at Watertown Arsenal affords to industry an opportunity to have such tests made at a reasonable cost and to contribute to the maintenance of an organization which is of great utility if not a necessity to the Ordnance Department.

The present installation at Watertown has been used in this way by industry to great advantage, and such use will increase as the possibilities of the process and its availability become better known. Its usefulness is, however, restricted by lack of ability to penetrate the heavier materials in use, and it is very desirable for industry, as well as for the work of the Government, that a 600,000-volt apparatus be provided.

A request for an appropriation for such a purpose is now before Congress and the Boiler Code Committee, realizing the importance of such facilities to the manufacturers of boilers and other pressure vessels to which its codes and their interpretations apply, is deeply interested in urging that the application receive favorable consideration of the Appropriation Committees in both houses.

Power Rights of Riparian Owners Upheld

Power rights of riparian owners, taken by the state in developing navigable streams, must be paid for by the state, the Court of Appeals ruled on Feb. 3. The ruling affirmed the decision of the Appellate Division, Third Department, which by a three to two vote upheld the Court of Claims in making an award of $250,000 to the Waterford Electric Light, Heat & Power Co. for the acquisition by the state of power rights and land along the Hudson River between Waterford and Mechanicville.

The New York Legislature of 1901 granted to the power company a franchise to construct a dam on its river bank property, but before work was begun the barge canal construction project was passed by the Legislature of 1903, providing for canalization of the river at this point and authorizing acquisition of the land. In 1910 the state took over the land and built a canal lock and dam where the Waterford company had planned to build its power house and dam.

The company brought action to recover $350,000, and a claim of $250,000 was allowed. It was the contention of the state that the company was entitled only to the value of the land acquired by the state, that all franchise grants of water power contain the reservation that the state has a right to improve navigation, and that canalization of the river was such an improvement. The company contended that the river was not navigable at its property because of rapids and a fall of eighteen feet.

President Desires Speed in St. Lawrence Study

The President, in a letter to the Speaker of the House, recently called attention to the fact that the Canadian government already has spent $247,931.26 in engineering studies on the St. Lawrence and has appropriated $150,000 for next season's work. The President states that "much definite information must be obtained to determine the best plan of development and a reliable estimate of its cost. The United States should bear a fair share in bringing the investigation to a conclusion. It is most desirable that we proceed as rapidly as possible to ascertain the cost of the project, the savings of cost that will be effected in transportation of the large quantities of grain and other materials we are moving east from the agricultural sections of our country and of the return cargoes that may be expected, as well as the extent to which it will be profitable to develop power on the St. Lawrence. I recommend that Congress take favorable action upon this request at an early date."

The proposal to expend the $275,000 for borings and other field work in connection with the St. Lawrence project, first was carried on the War Department appropriation bill. The appropriations committee insisted on being more circumspect in this instance, than in some others, with the result that the legislative authorization now is before Congress. The American members of the Joint Engineering Commission are particularly anxious to secure the appropriation so that the necessary arrangements can be made and contracts let for the boring which must be done at proposed dam sites.

Huge Merger in Bituminous Industry Likely

Plans are under way for a possible merger of bituminous coal properties valued at $100,000,000 in the Fairmount-Morgantown-Clarksburg district in northern West Virginia, according to an announcement made in the press recently by Flint & Co., Inc., and A. H. Bickmore & Co., organizers.

Charles R. Flint and A. H. Bickmore said that the merger involved more than 75,000 acres of developed coal lands, with 150 mines having an annual capacity of at least 21,000,000 tons. The proposal for a consolidation, they said, came from the West Virginia mine owners, and conference on the plan had reached a point which indicated a likelihood of an early development.

The coal operators, according to the organizers, felt that concentration of their properties under single operation would effect economies in operation, more centralized buying, higher mechanical efficiency, and a general decrease in selling costs.

Obituary

Lynn B. Easton, manager of the Laidlaw works of the Worthington Pump and Machinery Corp., died on Jan. 24, just before his fortieth birthday, at Cincinnati, Ohio. Mr. Easton had been connected for more than twenty years with the company, starting in the sales department and ending as manager of the works at Laidlaw, holding many other positions between these. His fine qualities, energy and genial personalty made him respected, loved and trusted by his numerous associates who mourn his passing.

Charles Hamilton Parker, superintendent of the generating department of the Edison Electric Illuminating Co. of Boston, with which he had been identified for 30 years, died on Jan. 28, at his home in Brookline, after an illness of more than a year. Born 51 years ago in Hong Kong, China, where his father was in business, he returned to America, where he entered the Massachussetts Institute of Technology from which he was graduated in 1895, going directly to the Edison Co. upon graduation. In a few years he became general superintendent of the generating department and his rare judgment in matters of company policy was always valued by his associates.

He served in the Spanish-American War, entering the Naval Brigade with the rank of lieutenant. In 1911 he was retired with the rank of captain. During the World War he was Chief of Bureau of the Massachusetts Public Safety Council and a member of the Naval Sub-base Committee. He was also given charge of the guard units on all Edison plants in Massachusetts. He was a member of the A.S.M.E., A.I.E.E. and other societies.

Personal Mention

William G. Christy has been appointed editor of *The Forge*, the bulletin of the St. Louis Section of the A.S.M.E., to succeed **Victr J. Azbe**, who has been editor for the last four years.

E. P. Lovejoy, Jr., of the General Electric Co. news bureau, has been transferred from Schenectady to New York City to represent the publicity department of the executive offices of the company.

Lee Cone Bullington, assistant manager of the power department of the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa., has been made manager of the company's Cincinnati office. He succeeds the late James A. Brett.

E. S. Reid has recently been made vice-president and consulting engineer for the Northern Engineering Works, Detroit, Mich., and **William Robertson** has been advanced to chief engineer, the position made vacant by the advance of Mr. Reid.

William F. Durand, president of the A.S.M.E., will start on a 6,000-mile trip to the Pacific Coast, visiting the various sections of the society on his way out and on the return trip. It is expected that he will visit ten sections and twelve engineering colleges where student branches are functioning. He expects to be gone until March 8.

Alfred F. Townsend, manager of the Eastern Texas Electric Co., of Beaumont and Port Arthur, has been appointed vice-president and general manager of the operating subsidiary companies of the Western United Corp., with headquarters at Aurora, Ill. These subsidiary companies have recently signed contracts with Stone & Webster, Inc., Boston Mass., for its executive management service. **J. G. Holtzclaw**, receiver and formerly manager of the Pensacola, Fla., Electric Co., succeeds Mr. Townsend as manager of the Eastern Texas Electric Co.

D. B. Rushmore, one of the consulting engineers of the General Electric Co., has resigned his position and after Feb. 1, will live at the University Club, New York City. Rest from desk work has been advised by his physician. Mr. Rushmore has been connected with the General Electric and the Stanley Electric Co., a company that was absorbed by the G.E., for about twenty-five years. Previous to his connection with this company he was connected with the Westinghouse Electric & Manufacturing Co., and also with the Royal Electric Co., of Montreal. He is a prominent member of several of the large engineering societies.

Society Affairs

The Baltimore Section of the A.I.E.E. will have as the attraction for its Feb. 20th meeting a paper on "The Klydonograph," by Dr. J. F. Peters, of the Westinghouse company.

The Milwaukee Section of the A.S.M.E. will consider some phase of refrigeration at its Feb. 18 meeting.

The Pittsburgh Section of the A. I. & S. E. E. will hear J. F. Howe on "A Discussion of Present Day Wire Rope Problems," at its meeting Feb. 21, which will be held at the William Penn Hotel.

The Colorado Section of the A.S.M.E. will hold a meeting on Feb. 16. William F. Durand, president of the A.S.M.E., will speak on "The Engineering Profession—Its Antiquity and Its Obligations."

The Plant Engineer's Club of Boston on Feb. 11 will hold a meeting which will be under the direction of the Edison Electric Illuminating Co. of Boston. "The Design and Operation of the New Weymouth Station," will be the subject.

Hartford Section of the A.S.M.E. will hold a meeting on Feb. 11 at the Engineer's Club. Prof. Wohlenberg of the Sheffield Scientific School, Mr. Bucanan of the Hartford City Gas Light Co. and C. W. Mayott of the Hartford Electric Light Co. will speak on "Combustion."

The American Society of Heating and Ventilating Engineers at its recent meeting in New York City on Jan. 27, elected the following officers for the year 1925-26: S. E. Dibble, president; William H. Driscoll, first vice-president; F. Paul Anderson, second vice-president; Perry West, treasurer; F. C. Houghten, secretary.

The New England Water Works Association will have two papers of interest to *Power* readers at its Feb. 10 meeting, to be held at the Boston City Club. They are: "The Electric Pumping Plant of the Kennebec Water District," by Arthur L. Shaw; "Some Results of Pipe Cleaning," by Burt B. Hodgman.

Business Notes

The Swartwout Co., Cleveland, Ohio, manufacturer of steam specialties, is announcing the appointment of J. W. Lytton as special factory representative for the installations and use of the company's products.

The Baker-Dunbar Co., Cleveland, Ohio, manufacturer of ash grates, hoppers, sluice ways, is announcing that as of Jan. 1, Wolss & Company, Wrigley Bldg., Chicago, Ill., has taken over representation for the company in that district.

The C. H. Williams Co., manufacturer of clamshell buckets, etc., Erie, Pa., announces that R. B. Randall, formerly Western sales manager of the Blaw-Knox Co., has been appointed its Western sales manager, with headquarters in Chicago.

The Bailey Meter Co., Cleveland, Ohio, announces that R. M. Hardgrove, formerly chief engineer, has been appointed research engineer; that R. D. Junkins, formerly manager of the Boston office, has been transferred to Cleveland to assume the duties of chief engineer; and that a new branch has been opened at Atlanta, with M. J. McWhorter in charge.

Coming Conventions

American Association of Oil Burner Manufacturers. Leod D. Becker, Bank of Galesburg Bldg., Galesburg, Ill. Convention and exhibit at Edgewater Beach Hotel, Chicago, April 1-3.

American Boiler Manufacturers Association. H. N. Covell, 191 Dikeman St., Brooklyn, N. Y. Midwinter meeting at Cleveland on Feb. 12.

American Ceramic Society. R. C. Purdy, Lord Hall, Ohio State University, Columbus, Ohio. Convention at Columbus, Ohio, Feb. 16-21.

American Electrochemical Society. Dr. Colin G. Fink, Columbia University, New York City. Convention at Niagara Falls, April 23-25.

American Institute of Electrical Engineers. F. L. Hutchinson, 29 West 39th St., New York City. Midwinter convention at New York City, Feb. 9-13. Convention at St. Louis, April 13-17.

American Institute of Mining and Metallurgical Engineers. F. F. Sharpless, 29 West 39th St., New York City. Annual meeting at New York City, Feb. 16-19.

American Society for Testing Materials. C. L. Warwick, 1315 Spruce St., Philadelphia, Pa. Annual meeting at Atlantic City, N. J., June 22-26.

American Society of Mechanical Engineers—Calvin W. Rice, 29 West 39th St., New York City. Spring meeting at Milwaukee, Wis., May 18-21.

American Water Works Association. W. N. Niesley, 170 Broadway, New York City. Convention at Louisville, Apr. 27-May 3.

Canadian Association of Stationary Engineers. Geo. J. Soucy, 48 Moore Ave., Toronto, Ont., Secy. Convention at Windsor, June 29-July 1.

Electric Power Club. S. N. Clarkson, B. F. Keith Bldg., Cleveland, Ohio. Convention at Hot Springs, Va., May 26-29.

Exposition of Inventions—American Institute, E. W. Bartlett, 47 West 34th St., New York City. Exposition at Engineering Societies Bldg., 29 West 39th St., New York City, April 27 to May 2.

Master Boiler Makers Association. H. D. Vought, 26 Cortlandt St., New York City. Convention at Chicago, May 19-22.

National Association of Stationary Engineers. F. W. Raven, 417 South Dearborn St., Chicago, Ill. National convention and exhibition at St. Paul, Minn., Aug. 31-Sept. 4. Annual conventions and exhibitions of state associations are scheduled as follows: **Pennsylvania Association** at Pittsburgh, Pa., May 15-16. Frank J. McCarron, 3647 North 11th St., Philadelphia, Pa. **Wisconsin Association** at Milwaukee, May 18-22. F. W. Horn, 256 29th St., Milwaukee, Wis. **New Jersey Association** at Atlantic City, June 4-8. H. W. Vail, 1244 Park Ave., Plainfield, N. J. **New York Association** at New York City, June 11-13, W. T. Meinzer, 3rd St., near Warburton, Bayside, L. I. **New England States Association** at Worcester, Mass., June 18-20. F. L. Tyler, 32 Briggs St., Taunton, Mass. **Ohio Association** at Middleton, Ohio, June 18-20. T. S. Garrett, 2622 East Second St., Dayton, Ohio. **Connecticut Association** at New Haven, June 25-27. George F. Klopfer, 30 East Pearl St., New Haven. **Minnesota Association** at St. Paul, Aug. 24-28. C. A. Nelson, 800 22nd Ave., Minneapolis, Minn.

National District Heating Association. D. L. Gaskell, Greenville, Ohio. Sixteenth annual convention at West Baden Springs Hotel, West Baden, Ind., May 19-22.

National Electric Light Association. M. H. Aylesworth, 29 West 39th St., New York City. Annual convention at San Francisco, June 15-20.

Society of Industrial Engineers. George C. Dent, 608 South Dearborn St., Chicago, National convention at Hotel Winton, Cleveland, Ohio, May 6-8.

Trade Catalogs

Instruments—The Foxboro Co., Inc., Neponset Ave., Foxboro, Mass. Leaflet "The Most Interesting Story Ever Told," describes the value of recording, indicating, etc., instruments.

Graphite Products — The United States Graphite Co., Saginaw, Mich. General catalog No. 23 covers the staple products furnished by this company. Lubricants, greases, boiler graphite, motor and generator brushes, manufactured by the company are described.

Engines, Diesel—Nordberg Manufacturing Co., Milwaukee, Wis., "Power with Profit," is a pamphlet containing a description of the Carthage, Mo., installation of Diesels in the municipal plant. Illustrations of the installation, curves of load, charts, tables of comparative power-generating costs for steam and Diesel plants are included.

Fuel Prices

COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines; *mine run* except Pittsburgh gas slack (*Coal Age*):

Bituminous, Net Tons	Market Quoting	Jan. 26, 1925
Pool 1	New York	$2.50@$3.00
Smokeless	Boston	1.72
Clearfield	Boston	2.10@ 2.50
Somerset	Boston	1.90@ 2.35
Kanawha	Columbus	1.50@ 1.70
Hocking	Columbus	1.50@ 1.75
Pittsburgh	Pittsburgh	1.90@ 2.00
Pittsburgh gas slack	Pittsburgh	1.50
Franklin, Ill.	Chicago	2.25@ 2.50
Central, Ill.	Chicago	2.15@ 2.25
Ind. 4th Vein	Chicago	2.25@ 2.50
West Ky.	Louisville	1.35@ 1.75
S. E. Ky.	Louisville	1.25@ 1.50
Big Seam	Birmingham	1.50@ 2.00
Anthracite Gross Tons		
Buckwheat No. 1.	New York	$2.25@$3.15
Buckwheat No. 1.	Philadelphia	2.50@ 3.00
Birdseye	New York	1.60@ 1.75

FUEL OIL

New York—Feb. 2, light oil, tank-car lots; 28@34 deg. Baumé, 5½c. per gal.; 36@40 deg., 5¾c. per gal., f.o.b. Bayonne, N. J.

St. Louis—Jan. 31, tank-car lots, f.o.b. St. Louis; 24@26 deg., $2.10 per bbl.; 26@28 deg., $2.15 per bbl.; 28@30 deg., $2.20 per bbl.; 30@32 deg., $2.25 per bbl.; 32@36 deg., gas oil, 5.651c. per gal.; 38@40 deg., 6.197c. per gal.

Pittsburgh—Jan. 29, f.o.b. local refinery; 30@34 deg., fuel oil, 6¼c. per gal.; 36@40 deg., fuel oil, 6½c. per gal.

Dallas—Feb. 2, f.o.b. local refinery, 26@30 deg., $1.90 per bbl.

Philadelphia — Jan. 30, 28@30 deg., $2.73@$2.793 per bbl.; 18@22 deg., $2.42@$2.483; 13@16 deg., $2.10@$2.163 per bbl.

Boston—Feb. 2, tank-car lots, f.o.b.; heavy oil, 21@14 deg., Baumé, 4⅝c. per gal.; light oil, 28@32 deg. Baumé, 5½c. per gal.

Cincinnati — Jan. 27, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 5¾c. per gal.; 26@30 deg., 5¾c. per gal.; 30@32 deg., 6½c. per gal.

New Plant Construction

Calif., Huntington Park — City, voted $55,000 bonds for waterworks, $31,000 to purchase present system and $24,000 for improvements including, 200,000 gal. elevated tank and tower, and 100,000 gal. reservoir, centrifugal pump, electric motor, fire hydrants, etc.

Calif., Los Angeles—Citizens Mortgage Co., awarded contract for the construction of a 13 story office building, at Broadway, 11th and 12th Sts., to the Vaughn Construction Co., 1018 Chapman Bldg., $692,-250. Steam heating plant and elevators not included in contract.

Calif., Los Angeles—Subway Terminal Corporation, c/o Schultze and Weaver, Pacific Mutual Bldg., Archts., will receive bids about February 25, for the construction of a terminal and office building, on Hill St. Estimated cost $2,000,000.

Calif., North Sacramento (Sacramento P. O.)—North Sacramento Land Co., 825 Jay St. is having plans prepared for the construction of canals to irrigate 800 acres, with pumping plants, including, two 10 in. centrifugal pumps, 7 cu.ft. capacity each, total lift 20 ft., direct connected to 40 hp. motors. Estimated cost $15,000. Company engineers in charge.

Calif., North Sacramento (Sacramento P. O.)—North Sacramento Light and Water Co., 825 Jay St. plans water works improvements, including 5 centrifugal pumps, 8 in., 4 sec. ft. capacity, 80 ft. total, direct connected to 300 hp. electric motors. Estimated cost $25,000. Private plans.

Calif., Pismo Beach—Pismo Beach Water Co., is receiving bids for the construction of a complete waterworks, including 2 wells, pump house, one motor driven high duty triplex pumping unit. Black and Veatch, Ferguson Bldg., Los Angeles, are engineers.

Calif., Salinas — Salinas Beverage Co., W. Voss and others, are having plans prepared for the remodeling of brewing plant into ice manufacturing plant, on North Main St. New equipment will be installed. Estimated cost $50,000.

Calif., San Pedro—Channel Construction Co., 1030 Bank of Italy Bldg., Los Angeles, awarded contract for the construction of a 10 story, office building on 1st St. and Front St. to Williams Construction Co., Marsh Strong Bldg., Los Angeles. Estimated cost $500,000.

Calif., Stockton—Western States Gas and Electric Co., is having plans prepared for improvements in San Joaquin Valley section. $300,000 will be expended here for 10,000 kw. rotary condensor, seven 333 kw. transformers, new gas plant, switching structure, 2nd high pressure line belt. Total estimate cost $2,000,000.

Calif., Watsonville—Pajaro Valley Cold Storage Co., 2nd and Walker Sts., plans the construction of a cold storage plant annex, with 50 ton ice making equipment.

Calif., Wheatland — City, will purchase emergency pumping plant for waterworks.

Colo., Denver—The Bureau of Reclamation, Department of the Interior, Denver, will receive bids until March 12th, for two hydraulic turbines each to deliver 750 hp. when operating at a head of 10 ft. and 1100 hp. when operating at a head of 14 ft.; two 1,000 kva generators, four 667 kva. transformers, switching apparatus and lightning arrester for siphon drop power plant, Yuma Project, Arizona-California. Elwood Mead, is commissioner.

D. C., Washington—Washington Modern Homes Co., 816 15th St., will soon receive bids, for the construction of a commercial hotel building, at 10th and E Sts. Estimated cost $1,000,000. J. W. Kearney, 1421 F St., is architect.

Fla., South Jacksonville—The city will vote on a $400,000 bond issue, March 3, for municipal improvements including electric light plant.

Fla., West Palm Beach—L. W. Tuller, Tuller Hotel, Detroit, Mich., plans the construction of a 14 story, hotel here. Estimated cost $2,000,000. L. Kamper, Kamper Bldg., Cass Ave., Detroit, is architect.

Ill., Pinckneyville—The city, J. C. Ham, Clk., will receive bids until February 16th, for one, 1400 gpm. centrifugal pump and motor; one 500 gpm. pump and motor; two, 600 gpm. pumps and motors; one, 500 gpm. fire pump and gasoline engine. A. H. Beard, 616 Title Guaranty Bldg., St. Louis, is engineer.

Ind., Evansville—Holt and Brandon Ice and Cold Storage Co., plans the construction of an ice and cold storage plant addition, on Walnut St. Estimated cost $160,-000.

Ia., Ottumwa—St. Joseph's College, will soon award contract for the completion of 4 story, hospital building, including boiler house and laundry. Estimated cost $450,-000. E. Brielmaier & Sons, 432 Broadway, Milwaukee, are architects.

Kan., Kansas City—G. T. Darby, Purch. Agt. will receive bids until February 10, for two, 4,000,000 gal. capacity motor driven centrifugal pumps, for booster service.

Md., Baltimore—Standard Electric Machinery Co., 9 East Hill St. in the market for 15 hp. GE-KT, 752 form C, 3 ph., 60 cy., 220 v. bare motor, as duplicate unit on pump; 125 or 150 hp. slipring 3 hp. 60 cy., 220 v. motor and drum starter, also M-G set gen. d.c. 115 v. motor, slipring 3 ph., 60 cy. 220 v. compr. starter, and generator panel.

Mass., Truro—L. C. Greenleaf, 101 Tremont St., Boston, is in the market for equipment for electric light plant here including engine, generator, pumps, batteries, etc.

Minn., Winona—Bd. of Education, A. H. Krossin, Clk., awarded contract for the construction of a 3 story high school, including power house, to Carlsted Bros., 700 Builders Exchange, Minneapolis, $206,026.

Mo., Kansas City—Westport Hotel Operating Co., c/o J. J. Taxman, Land Bank Bldg., awarded contract for the construction of a 12 story hotel, at 14th and Baltimore Sts., to George H. Siedhoff Construction Co., Broadview Hotel Bldg., Wichita, Kansas.

Mo., Kansas City—E. J. Willet, 806 Lathrop Bldg., will soon receive bids for the construction of a 12 story theater and office building, at Broadway and Valentine Rd. R. Gornall, 203 Bruening Bldg., is architect.

Mo., St. Louis—Western Union Telegraph Co., 514 Olive St., awarded contract for the construction of a 17 story office building, at Ninth and Chestnut Sts., to Dwight P. Robinson Construction Co., 655 Park Ave., New York City.

N. J., Little Falls—The City will receive bids until April 15, for the extension of the sewerage system, and construction of a pumping station. Estimated cost $145,000. H. J. Harder, 129 Market St., Paterson, is engineer.

N. Y., North Tarrytown—Bd. of Trustees, T. A. Quinn, Clk., Beekman Ave., will receive bids until Feb. 20th, for the construction of water supply system including, pumping station, equipment, distributing mains, valves, hydrants, etc., and also 750,000 gal. elevated tank

N. C., Biscoe—D. A. Monroe, plans the construction of a hydro-electric power plant, of several hundred horsepower at the Norman Mill, on Gum Swamp, Scotland County.

Okla., Altus—City, is in the market for a new 750 hp. Diesel oil engine generator unit, for electric light plant. M. M. Oates, is city clerk.

Okla., Morrison—The City, voted $27,000 bonds for the construction of a water works system, including well, deep well pump, tank, valves, hydrants and mains. Homer Olmsted, 2230 West 18th St., Oklahoma City, is engineer.

Okla., Wetumka — The City, awarded contract for the construction of a water purification and power plant, including 4 motor driven pumps, 6 hydrants, 4 valves, two 400 hp., engines, etc., to Conner Construction Co., Rialto Bldg., Kansas City, Mo. $105,374. V. V. Long & Co., Oklahoma City, is engineer.

Pa., Germantown (Philadelphia P. O.)—Germantown Dispensary & Hospital, will receive bids until February 20, for the construction of 3 hospital buildings. Arthur H. Borckie, 254 So. 15th St., Philadelphia, is architect.

Pa., Philadelphia—Gimbel Brothers, 9th and Market Sts., Philadelphia, awarded contract for the construction of a department store, to Thompson Starrett Co., 49 Wall St., New York City. Estimated cost $1,000,000.

Tenn., Milan — The City voted $40,000 bonds for extensions of light and water plants.

Tex., Colorado—West Texas Electric Co., is having plans prepared for the construction of a combination ice factory and cold storage plant. Estimated cost $75,000. Private plans. Complete machinery to be purchased.

Tex., Dallas—Adolphus Hotel Co., c/o R. B. Ellis, Jr., awarded contract for the construction of a 22 story hotel on Main St. to Henger & Chambers, Slaughter Bldg., Dallas. Estimated cost $1,000,000.

Tex., Denton—W. T. Bolton, is having plans prepared for the construction of a cold storage plant, here. Estimated cost $45,000. Private plans.

Tex., Houston—Sakowitz Bros., c/o T. Sakowitz, Main and Preston Sts., plan the construction of a 12 or 15 story office building on Main St. Estimated cost $1,000,000. Architect not announced.

Tex., Leonard—Leonard Ice and Fuel Co., c/o manager, will soon receive bids for a 50 or 75 hp., Fairbanks-Morse type, or equal Y engine, belt drive. (New or used).

Tenn., Nashville—Bennie—Dillion Building Co., W. W. Dillion, Pres. will soon receive bids for the construction of a 12 story, office building, at 7th and Church Sts. Estimated cost $700,000. Asmus & Clark, Stallman Bldg., are architects.

Tex., Palestine—Palestine Ice and Fuel Co., c/o S. L. Watts and P. Horton, Tyler, Tex., Engrs., will build ice, cold storage and fuel plant, here. Estimated cost $45,000.

Tex., San Angelo—Middlewest Utilities Company, 72 West Adams St., Chicago, Ill., is having plans prepared for the construction of an ice plant, here. Complete equipment, including 75 ton ice plant machinery will be required. Estimated cost $75,000. M. J. Insull, is president.

Tex., Wellington—C. B. Meyers, Clk., will receive bids until February 16, for 400 hp. Diesel oil engine generator unit, for city light plant, including exciter, switchboard and power wiring. Estimated cost $45,000. L. J. Leggitt, is engineer.

Tex., Weslaco—The city, R. E. Snodgrass, Mayor, will hold an election February 9, to vote on a $20,000 bond issue for water supply improvement, including pumping plant. H. E. Bennett, Mercedes, is engineer.

Wash., Aberdeen—The Grays Harbor Railway and Light Co., P. A. Bertrand Mgr., applied to the State Supervisor of Hydraulics, Olympia, for a new permit for rights on the Wynooche River. The plans include a $1,700,000 development, with 10,000 hp. plant, a dam 150 ft. high and 300 ft. across the top, impounding 80,000 acre ft. of water. Company has also filed permit for water rights prefacing the development of a 29,000 hp. hydro-electric plant, on the Hoh River, Jefferson County.

Ont., Toronto — Hydro Electric Power Commission of Ontario, 190 University Ave., is having plans prepared for the construction of an auxiliary steam driven electric generating station, 100,000 hp. capacity, to supplement Niagara power system. Equipment, including boilers, stokers, feed water pump, coal and ash handling equipment, turbines, engines, generators, transformers, switchboard, etc., will be required. Estimated cost $5,000,000. F. A. Gaky is chief engineer.

Que., Montreal — Canadian Paperboard Co., 2 Seigniers St., plans the installation of 400 hp. steam power plant; equipment, including stokers, economizers, coal storage, coal elevator, bunker and weighing apparatus, feed pump, preheater, fan, motor, steam engine, chimney, etc., will be required. Boilers have been purchased. Kerry & Chase Ltd., 550 Confederation Life Bldg., Toronto, Ont., are engineers and will purchase equipment.

Ont., Waterford—Town is having plans prepared for construction of a water-works system, including centrifugal three stage electric pumps, reservoir, etc. Estimated cost $50,000. James, Proctor, Redfern, 36 Toronto St., Toronto, are engineers.

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

SINCE LAST MONTH

Prices of iron, steel, lumber, cement, railway supplies and paint materials are higher than a month ago. In electrical supplies there is some fluctuation of armored cable quotations and a decidedly upward trend in flexible cord. The most marked price advances occurred in linseed oil and non-ferrous metal products. Raw oil is up 8 to 18c. per gal. from the Jan. 13 level. Red and white lead, following the pig metal market, rose ½c. per lb. in the middle of the month and then slumped back to the Jan. 1 level. Refractories prices are less firm than a month ago.

POWER-PLANT SUPPLIES

HOSE—Quotations at New York warehouses:

	Fire Protection	50-Ft. Lengths
Underwriters' 2½-in., coupled, single jacket		56c. per ft.
Common, 2½-in., cotton-rubber lined	80c. per ft. list less	45%

Air—Best grade

¾-in., per ft.	3-ply....$0.33	4 ply....$0.40	

Steam—Discounts from List

First grade....40%	Second grade....40–5%	Third grade..40–10%

RUBBER BELTING—List price 6-in., 6 ply, $1.83 per lin.ft. The following discounts from list apply to rubber transmission belting:

Best grade....50–5%	Second grade....50–10–5%

LEATHER BELTING—List price, 24c. per lin.ft. per inch of width for single ply at New York warehouses.

Grade	Discount from list
Medium	40–2½%
Heavy	30–5%

RAWHIDE LACING { For cut, best grade, 45–5%, 2nd grade, 55%. For laces in sides, best, 41c. per sq.ft.; 2nd, 37c. Semi-tanned: cut, 45–5%; sides, 41c. per sq.ft.

PACKING—Prices per pound at New York warehouses:

Rubber and duck for low-pressure steam, ⅛ in.	$0.90
Asbestos for high-pressure steam, ⅛ in.	1.70
Duck and rubber for piston packing	.90
Flax, regular	1.10
Flax, waterproofed	1.70
Compressed asbestos sheet	.80
Wire insertion asbestos sheet	1.30
Rubber sheet	.45
Rubber sheet, wire insertion	.70
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.25
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.30
Asbestos wick, ½- and 1-lb. balls	.50

PIPE AND BOILER COVERING—Discounts, New York warehouses, are as follows:

85% magnesia high pressure		50%
For low-pressure heating and return lines	4-ply	70%
	3-ply	72%
	2-ply	74%

PORTLAND CEMENT—New York, $2.50@ $2.60 per bbl. without bags, in carload lots delivered on job. Bag charge of 40c. per bbl.

STRUCTURAL STEEL—New York delivered price, 3 to 15-in. beams and channels and 3 to 6-in. angles, tees, and plates, all $3.34 per 100 lb.

COTTON WASTE—The following prices are in cents per pound:

	New York	Cleveland	Chicago
White	15@22	19.00	.14@.16
Colored	10.00@15.50	18.00	.09½@.12½

WIPING CLOTHS—Jobbers' prices, in cents per lb., as follows:

	13½ x 13½	13½ x 20½
Chicago	11.00	11.00
New York (white, at washeries)	12.00	.....
Cleveland	$36.00 per M.	$50.00 per M.

LINSEED OIL—These prices are per gallon:

	New York	Cleveland	Chicago
Raw in barrels (5 bbl. lots)	$1.26	$1.33	$1.25

WHITE AND RED LEAD—In 100-lb. kegs, base price in cents per pound:

	Dry		In Oil	
	Current	1 Yr. Ago	Current	1 Yr. Ago
Red	16.25	14.00	17.75	15.50
White	16.25	14.00	16.25	14.00

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

Rivets, $\frac{7}{16}$x1-in. and longer, 19c. per lb., less 60% at New York warehouses. Same discount for tinned. EXTRA per 100 lb. for 1½ to 2-in. long, all diameters, 25c.; ¾-in. dia., 35c.; ½-in., dia., 75c.; 1-in. long and shorter, 75c.; longer than 5-in., 50c.; less than 200 lb., 50c.; countersunk heads, 45c.

Structural rivets, ¾, ⅞, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.:
New York....$4.25 Chicago....$3.50 Pittsburgh....$2.60
Boiler rivets, same sizes:
New York....$4.35 Chicago....$3.70 Pittsburgh....$2.90

REFRACTORIES—Prices in carlots f.o.b. plant:

Chrome brick, eastern shipping points	net ton	$47@52
Chrome cement, 40@ 50% Cr_2O_3, in bulk	net ton	22@27
Chrome cement, 40@ 50% Cr_2O_3, in sacks	net ton	26@31
Magnesite brick: 9-in. straights	net ton	65@68
Magnesite brick: 9-in. arches, wedges and keys	net ton	71.50@74.80
Magnesite brick: Soaps and spits	per ton	91.00@95.20
Silica brick: Mt. Union, Pa.	per M	38@40
Clay brick, 1st quality, 9 in. shapes, Pennsylvania	per M	40@47
Clay brick, 1st quality, 9 in. shapes, Ohio	per M	43@46
Clay brick, 1st quality, 9 in. shapes, Kentucky	per M	43@45
Clay brick, 2nd quality, 9 in. shapes, Pennsylvana	per M	33@40
Clay brick, 2nd quality, 9 in. shapes, Ohio	per M	40@43
Clay brick, 2nd quality, 9 in. shapes, Kentucky	per M	40@43
Chrome ore crude, 40@50%	net ton	18.00@19.50

BABBITT METAL—Warehouse prices in cents per pound:

	New York	Cleveland	Chicago
(83% tin)	60.00	68.50	50.00
(35% tin)	28.00	21.50	28.00

COLD DRAWN STEEL—Warehouse prices are as follows:

	New York	Cleveland	Chicago
Round shafting and screw stock, per 100 lb. base	$4.15	$4.00	$3.80
Flats, squares and hexagons, per 100 lb. base	4.65	4.50	4.30

BOILER SPECIALTIES—F. o. b. New York or Jersey City, discounts on list:

	Current
Copper ferrules	70%
Boiler flanges	60-10%
Boiler stay bolts	60%
Boiler patch bolts	10%
Boiler fitting-up bolts	45%
Pressed steel boiler lugs	10%
Pressed steel boiler hangers	10%

WROUGHT PIPE—The following discounts are to jobbers for carload lots at Pittsburgh mill:

BUTT WELD

Inches	Steel Black	Galv.	Inches	Iron Black	Galv.
1 to 3	62	50½	1 to 1½	30	13

LAP WELD

2	55	43½	2	23	7
2½ to 6	59	47½	2½	26	11
7 and 8	56	43½	3 to 6	28	13
9 and 10	54	41½	7 to 12	26	11
11 and 12	53	40½			

BUTT WELD, EXTRA STRONG, PLAIN ENDS

1 to 1½	60	49½	1 to 1½	30	14
2 and 3	61	50½			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	53	42½	2	23	9
2½ to 4	57	46½	2½ to 4	29	15
4½ to 6	56	45½	4½ to 6	28	14
7 and 8	52	39½	7 and 8	21	7
9 and 10	45	32½	9 to 12	16	2
11 and 12	44	31½			

BOILER TUBES—Following are prices in New York warehouse of tubes manufactured according to specifications of the American Society of Mechanical Engineers:

Size	Lapweld Steel	C. C. Iron	Seamless Steel
1	.....	.....	$0.23
1¼	.....	.....	.25
1½	.....	.....	.22
1¾	$0.26	$0.29	.23
2	.20	.25	.21
2¼	.23	.29	.23
2½	.24	.33	.28
2¾	....	....	....
3	.30	.41	.32
3¼	.32	.47	.35
3½	.34	.51	.37
4	.43	.64	.47

Tubes 2½ in. diameter, or smaller, over 18 ft. long, 10 per cent extra.

These prices are net per lineal foot based on stock lengths. If cut to special lengths, billing will be based on the entire stock lengths.

In addition to the above, standard cutting charges are as follows:

1¼ in. to 2 in. diameter, 5c. per cut. 2¾ in. diameter, 7c. per cut
2½ in. diameter, 6c. per cut. 3 in. diameter, 9c. per cut
3½ in. to 4 in. diameter, 10c.

ELECTRICAL SUPPLIES

ARMORED CABLE—Price per 1,000 ft.—5 per cent 10 days.

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$39.00 (net)	$ 53.50 (net)	$164.00	$210.00
No. 12 solid	135.00	170.00	225.00	265.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	.....

From the above lists discounts are:		Lead Covered
Less than coil lots	50%	25%
Coils to 1,000 ft.	55%	30%
1,000 to 5,000 ft.	60%	35%
5,000 ft. and over	60–5%	40%

CONDUIT, Price per 1,000 ft.; **ELBOWS AND COUPLINGS**, Per 100 pieces, f.o.b. New York, with 10-day discount of 5 per cent.

Size In.	Conduit Black Per M	Conduit Galvanized Per M	Elbows Black Per C	Elbows Galvanized Per C	Couplings Black Per C	Couplings Galvanized Per C
¾	$58.92	$63.77	$9.56	$10.64	$5.52	$5.92
¾	75.35	81.90	12.58	14.01	7.88	8.45
1	108.15	117.84	18.62	20.73	10.25	10.99
1¼	146.33	159.44	24.78	27.35	14.21	15.18
1½	174.96	190.63	33.04	36.46	17.55	18.75
2	235.39	256.48	60.58	66.85	23.41	25.00
2½	372.18	405.52	99.13	109.39	33.43	35.71
3	486.69	530.30	264.34	291.70	50.14	53.56
3½	611.52	663.96	583.74	644.16	66.86	71.42
4	745.53	807.36	674.61	774.43	83.57	89.27

CONDUIT BODIES AND FITTINGS—Black or galvanized.

	Less than $10 list	$10 list to $100	$100 list and over
Standard package	10%	20%	28%
Less than standard package	5%	10%	20%

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.12	D. P. D. B.	$0.31
D. P. M. L.	.16	T. P. S. B.	.35
T. P. M. L.	.27	T. P. D. B.	.47
D. P. S. B.	.16		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.27	$0.70	$1.75
T. P. M. L.	.40	1.00	2.30
D. P. S. B.	.35	.87	.....
T. P. S. B.	.67	1.50	.....
D. P. D. B.	.65	1.75	.....
T. P. D. B.	1.12	3.00	.....
T. P. to D. P. D. B.	.75	2.10	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton reinforced heavy	$23.00
No. 16 cotton reinforced heavy	26.50
No. 18 cotton reinforced light	18.25
No. 16 cotton reinforced light	23.00
No. 18 cotton Canvasite cord	17.50
No. 16 cotton Canvasite cord	20.50

NATIONAL ELECTRIC CODE FUSES, NON-REFILLABLE—

250-Volt	Std. Pkg.	List	600-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	$0.15	3-amp. to 30-amp.	100	$0.30
35-amp. to 60-amp.	100	.30	35-amp. to 60-amp.	100	.60
61-amp. to 100 amp.	50	.90	65-amp. to 100-amp.	50	1.50
101-amp. to 200-amp.	25	2.00	110-amp. to 200-amp.	25	2.50
201-amp. to 400-amp.	25	3.60	225-amp. to 400-amp.	25	5.50
401-amp. to 600-amp.	10	5.50	450-amp. to 600-amp.	10	8.00

Discount: Less 1-5th standard package, 55%; 1-5th to standard package, 60%; standard package, 65%.

RENEWABLE FUSES, ENCLOSED—List price each:

Sizes	250-Volt List-Price	600-Volt List-Price	Std. Pkg. Quantity	Carton Quantity
1 to 30-amp.	$0.50	$1.10	100	10
35 to 60-amp.	1.00	1.25	100	10
65 to 100-amp.	2.00	3.00	50	5
110 to 200-amp.	4.00	5.00	25	5
225 to 400-amp.	7.50	11.00	25	1
450 to 600-amp.	11.00	16.00	10	1
450 to 600-amp.	11.00	16.00	10	1

REFILLS—

1 to 30	$0.30 ea.	$0.05	100	100
35 to 60	.05 ea.	.06	100	100
65 to 100	.10 ea.	.10	50	50
110 to 200	.15 ea.	.15	25	50
225 to 400	.30 ea.	.30	25	25
450 to 600	.60 ea.	.60	10	10

Discount Without Contract—Fuses:	
Broken carton	5%
Unbroken carton but less than std. pkg.	22%
Std. pkg.	40%
Discount Without Contract—Renewals:	
Less than std. pkg.	Net list
Standard package	40%
Discount With Contract—Fuses:	
Broken cartons	10%
Unbroken cartons but less than standard package	26%
Standard package	42%
Discount With Contract—Renewals:	
Less standard package	Net list
Standard package	42%

FUSE PLUGS, MICA CAP—

0–30 ampere, standard package (500)	$2.85
0–30 ampere, less than standard package	3.15

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs Mazda B— Watts	Plain	Frosted	No. in Package	Pear-Shaped Bulbs or Bowl Enameled Mazda C— Watts	Clear	Frosted	No. in Package
10	$0.27	$0.32	120	50	$0.40	$0.45	60
15	.27	.32	120	75	.45	.55	60
25	.27	.32	120	100	.50	.55	24
40	.27	.32	120	150	.65	.70	24
50	.27	.32	120	200	.80	.85	24
60	.32	.37	120	300	1.25	1.35	24
				500	2.00	2.15	12
				750	3.50	3.70	8
				1,000	3.75	3.95	8

Standard pkg. quantities are subject to discount of 10% from list. Annual contracts ranging from $75.00 to $300,000 net allow a discount of 15 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0.18
Composition 2-piece attachment plug	.27
Swivel attachment plug	.12
Small size—2 Pc. Plug—Composition	.08½

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f. o. b. New York:

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$7.29	$9.38	$11.28	$17.95
12	9.66	12.45	14.17	23.62
10	12.86	16.33	18.06	32.02
8	18.17	21.78	24.15	36.75
6	.....	.....	34.38	.....
4	.....	.....	47.75	.....
2	.....	.....	70.35	.....
1	.....	.....	89.73	.....
0	.....	.....	120.48	.....
00	.....	.....	144.90	.....
000	.....	.....	172.20	.....
0000	.....	.....	204.75	.....

SOCKETS, BRASS SHELL—

½ In. or Pendant Cap Key Each	Keyless Each	Pull Each	¾ In Cap Key Each	Keyless Each	Pull Each
$0.33	$0.30	$0 55	$0.39	$0 36	$0.61

Less 1-5th standard package	25%
1-5th to standard package	32%
Standard package	37%

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 33c. lb., 100 lb. lots	31c. lb.
Rubber tape, ¾ in., less 100 lb. 33c. lb., 100 lb. lots	31c. lb.
Wire solder, less 100 lb. 27c. lb., 100 lb. lots	29c. lb.
Soldering paste, 2 oz. cans	$1.00 doz.

ENCLOSED SWITCHES, KNIFE—Safety type, externally operated, 250 d.c or a.c., N.E.C.

TYPE "C" FUSED BOTTOM

Size, Amp.	Double Pole, Each	Three Pole, Each	Four Pole, Each
30	$4.50	$6.00	$7.25
60	7.50	8.25	10.50
100	10.50	13.00	22.50
200	16.00	20.00	36.00

Discounts:	
Less than $25.00 list value	30%
$25 to $50 list value	30–5%
$50 list value or over	35%